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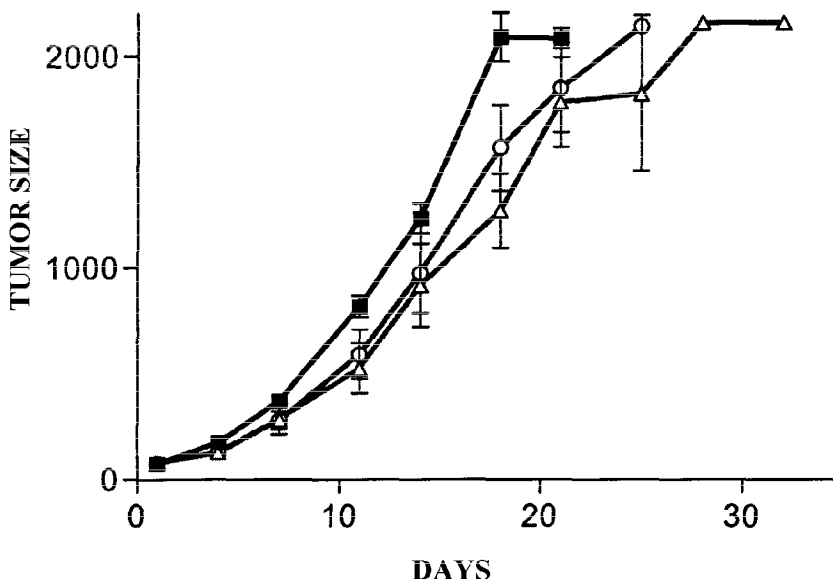
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(54) Title: PYRAZINE DERIVATIVES AS MODULATORS OF TYROSINE KINASES



(57) Abstract: The present invention provides pyrazine derivatives that inhibit tyrosine kinase activity. Certain pyrazine derivatives are selective inhibitors of vascular endothelial growth factor (VEGF) receptor tyrosine kinase. The present invention also provides pharmaceutical formulations containing the pyrazine derivatives and methods of use of these formulations as anti-tumor agents and to treat solid-tumor cancers, angiogenesis, diabetic retinopathy, rheumatoid arthritis, endometriosis and psoriasis.



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## PYRAZINE DERIVATIVES AS MODULATORS OF TYROSINE KINASES

## FIELD OF THE INVENTION

5 This invention claims priority from U.S. Provisional Application No. 60/233,968 filed September 20, 2000 and entitled "Pyrazine Derivatives as Modulators of Tyrosine Kinases."

The present invention provides pyrazine derivatives that inhibit tyrosine kinase activity. Certain pyrazine derivatives are selective inhibitors of the vascular endothelial growth factor (VEGF) receptor tyrosine kinase. The present invention also provides pharmaceutical formulations containing the pyrazine derivatives and methods for use of these formulations as anti-tumor agents, and to treat diabetic retinopathy, rheumatoid arthritis, endometriosis, and psoriasis.

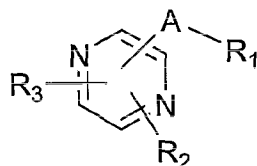
## 15 BACKGROUND OF THE INVENTION

Angiogenesis plays a role in various processes including development of the vasculature, wound healing and maintenance of the female reproductive system. Pathological angiogenesis is associated with disease states such as cancer, diabetic retinopathy, rheumatoid arthritis, endometriosis and psoriasis. Solid-tumor cancers, in particular, are dependent on angiogenesis for their growth. The vascular endothelial growth factors (VEGFs) are mediators of both normal and pathologic angiogenesis. VEGF transmits signals into cells through their cognate receptors, which belong to the receptor tyrosine kinase (RTK) family of transmembrane receptors. These receptors are tripartite, consisting of an extracellular ligand-binding domain, a transmembrane domain, which anchors the receptor in the membrane of the cell, and an intracellular tyrosine kinase domain. One subfamily of RTKs comprises the receptors Flt1/VEGF-R1 and KDR/Flk1/VEGF-R2, which bind VEGFs. Binding of the VEGF ligand to the receptor results in stimulation of the receptor tyrosine kinase activity and transduction of biological signals into the cell. The KDR/Flk1/VEGF-R2 receptor mediates the biological activities of mitogenesis and proliferation of endothelial cells while the Flt1/VEGF-R1 receptor mediates functions such as endothelial cell adhesion. Inhibition of KDR/Flk1/VEGF-R2 signalling has been

shown to inhibit the process of angiogenesis. Inhibitors of this receptor are likely useful in controlling or limiting angiogenesis.

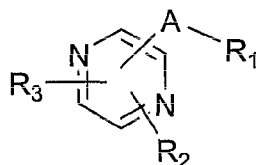
## SUMMARY OF THE INVENTION

5           The present invention provides pyrazine derivative compounds that display activity as kinase inhibitors of the formula:



where the substituents are defined herein. These pyrazine derivatives are useful as kinase inhibitors; particularly, as inhibitors against the kinase domain of the Vascular Endothelial Growth Factor Receptor (VEGF-R), inhibiting the activity of the VEGF receptor *in vitro* and *in vivo*.

In a preferred embodiment, the invention relates to compounds of Formula 1:



or a pharmaceutically acceptable salt thereof, wherein

R<sub>1</sub> is selected from the group consisting of cycloalkyl, heterocyclyl, biheterocyclyl, aryl, biaryl, heteroaryl and biheteroaryl optionally substituted with 1 to 5 substituents independently selected from the group consisting of alkyl, lower alkyl, alkenyl, alkynyl, alkoxy, lower alkoxy, heterocyclyl, heterocyclylalkyl, heterocyclylalkenyl, heterocyclylalkynyl, heterocyclylalkoxy, aryl, arylalkyl, arylalkenyl, arylalkynyl, arylalkoxy, heteroaryl, heteroarylalkyl, heteroarylalkenyl, heteroarylalkynyl, heteroarylalkoxy, OH, hydroxyalkyl, halogen, cyano, nitro, amino, alkylamino, alkylaminoalkyl, alkylaminoalkylamino, aminoalkyl, aminoalkylamino, di(alkyl)amino, di(alkyl)aminoalkyl, di(alkyl)aminoalkylamino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, carbamoyl, acyl, acylalkyl, alkoxycarbonyl, alkoxycarbonylalkyl, acylamino,

- alkylsulfonyl, alkylsulfonylamino, arylsulfonylamino (wherein aryl is substituted with 1 to 3 substituents independently selected from the group consisting of cyano, halogen, hydroxy, nitro, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy), aminosulfonyl, aminosulfonylalkyl, 5 alkylaminosulfonyl, alkylaminosulfonylalkyl, di(alkyl)aminosulfonyl, di(alkyl)aminosulfonylalkyl, carboxyl, (hydroxyalkyl)carbonyl, (hydroxyalkoxy)carbonyl, trihalo substituted lower alkyl and trihalo substituted lower alkoxy;
- 10 A is selected from the group consisting of  $-N(R_4)(CH_2)_x-$ ,  $-O(CH_2)_x-$ ,  $-S(CH_2)_x-$ ,  $-SO_2(CH_2)_x-$ ,  $-SO_2N(CH_2)_x-$ ,  $-NSO_2(CH_2)_x-$ ,  $-N(R_4)(CH_2)_{1-4}O(CH_2)_x-$ ,  $-N(R_4)(CH_2)_{1-4}NH(CH_2)_x-$ ,  $-N(R_4)CONH(CH_2)_x-$  and  $-N(R_4)CNNH(CH_2)_x-$ ; wherein x is an integer from 0 to 4;
- 15  $R_4$  is selected from the group consisting of H, lower alkyl, alkyl, hydroxyalkyl, alkoxyalkyl, arylalkyl, lower alkenyl, alkenyl, aryl and heteroaryl; wherein aryl and heteroaryl are optionally substituted with 1 to 5 substituents independently selected from the group consisting of OH, halogen, cyano, nitro, amino, alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, 20 di(hydroxyalkyl)amino, alkyl, lower alkyl, alkoxy, lower alkoxy, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy;
- $R_2$  is selected from the group consisting of heteroaryl and biheteroaryl optionally substituted with 1 to 2 substituents independently selected from  $R_7$  and 1 25 substituent selected from  $R_8$ ;
- $R_7$  is selected from the group consisting of alkyl, lower alkyl, alkoxy, lower alkoxy, alkenyl, alkynyl, heterocyclyl, heterocyclylalkyl, heterocyclylalkoxy, aryl, arylalkyl, arylalkoxy, OH, hydroxyalkyl, halogen, cyano, nitro, amino, 30 alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, carbamoyl, acyl, acylalkyl, alkoxycarbonyl, alkoxycarbonylalkyl, acylamino, alkylsulfonyl, alkylsulfonylamino, arylsulfonylamino (wherein aryl is substituted with 1 to 3 substituents independently selected from the group consisting of cyano, halogen, hydroxy, nitro, tri(halo)substituted lower alkyl

and tri(halo)substituted lower alkoxy), carboxyl, (hydroxyalkyl)carbonyl, (hydroxyalkoxy)carbonyl, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy;

- 5  $R_8$  is selected from the group consisting of alkyl, OH, hydroxyalkyl, halogen, cyano, amino, alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, carbamoyl, alkylcarbonylamino, alkylcarbonyl, alkoxy carbonyl, (hydroxyalkyl)carbonyl, (hydroxyalkoxy)carbonyl,  $O(CH_2)_nR_5$ ,  $O(CH_2)_nO(CH_2)_mR_5$ ,  $O(CH_2)_nCH[(CH_2)_mR_5]_2$ ,  
 10  $O(CH_2)_nN[(CH_2)_mR_5]_2$ ,  $OCON[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nR_5$ ,  $NH(CH_2)_nCH(R_5)_2$ ,  $NH(CH_2)_nSO_2(CH_2)_mR_5$ ,  $NH(CH_2)_nO(CH_2)_mR_5$ ,  $NH(CH_2)_nOCH[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nO(CH_2)_mO(CH_2)_mR_5$ ,  $NH(CH_2)_nN[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nSO_2NH(CH_2)_mR_5$ ,  $NH(CH_2)_nCH(OH)(CH_2)_mR_5$ ,  $NH(CH_2)_nCH(OH)(CH_2)_mOR_5$ ,  $NH(CH_2)_nCH(OH)(CH_2)_mN[(CH_2)_mR_5]_2$ ,  
 15  $NH(CH_2)_nCO(CH_2)_mN[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nCO_2(CH_2)_mR_5$ ,  $NH(CH_2)_nCO(CH_2)_mSO_2NH(CH_2)_mR_5$ ,  $NHCO(CH_2)_nCH(R_5)_2$ ,  $NHCO(CH_2)_nR_5$ ,  $NHCO(CH_2)_nO(CH_2)_mR_5$ ,  $NHCO(CH_2)_nO(CH_2)_mO(CH_2)_mR_5$ ,  $NHCO(CH_2)_nO(CH_2)_mCO(CH_2)_mR_5$ ,  $NHCO(CH_2)_nN[(CH_2)_mR_5]_2$ ,  $CONH(CH_2)_nO(CH_2)_mR_5$ , and  
 20  $CONH(CH_2)_nN[(CH_2)_mR_5]_2$ ; wherein n is an integer from 0 to 6 and m is an integer from 0 to 4; with the proviso, that m is at least 1 when  $R_5$  is selected from the group consisting of OH, amino, alkylamino and di(alkyl)amino;

- $R_5$  is selected from the group consisting of H, OH, lower alkyl, amino,  
 25 alkylamino, di(alkyl)amino, aryl, heteroaryl, biheteroaryl and heterocyclyl; wherein aryl, heteroaryl and heterocyclyl are optionally substituted with 1 to 3 substituents independently selected from the group consisting of alkyl, lower alkyl, acyl, carboxyl, aryl (optionally substituted with 1 to 5 halogen substituents), OH, halogen, cyano, amino, alkylamino, di(alkyl)amino,  
 30 (hydroxyalkyl)amino, di(hydroxyalkyl)amino, alkylsulfonyl, aminosulfonyl, alkylaminosulfonyl and aminosulfonylalkyl; and, wherein heterocyclyl is further optionally substituted with 1 to 3 oxo substituents; and,

$R_3$  is selected from the group consisting of H, alkyl, lower alkyl, alkoxy, lower

alkoxy, alkenyl, alkynyl, heterocyclyl, heterocyclylalkyl, heterocyclylalkoxy, aryl, arylalkyl, arylalkoxy, OH, hydroxyalkyl, halogen, cyano, nitro, amino, alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, carbamoyl, acyl, acylalkyl, alkoxycarbonyl, alkoxycarbonylalkyl, acylamino, alkylsulfonyl, alkylsulfonylamino, arylsulfonylamino (wherein aryl is substituted with 1 to 3 substituents independently selected from the group consisting of cyano, halogen, hydroxy, nitro, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy), carboxyl, (hydroxyalkyl)carbonyl, (hydroxyalkoxy)carbonyl, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy.

In one aspect of this embodiment, the compound of claim 1 includes R<sub>1</sub> wherein R<sub>1</sub> is selected from the group consisting of cycloalkyl, heterocyclyl, biheterocyclyl, aryl, biaryl, heteroaryl and biheteroaryl optionally substituted with 1 to 5 substituents independently selected from the group consisting of alkyl, lower alkyl, alkenyl, alkynyl, alkoxy, lower alkoxy, heterocyclyl, heterocyclylalkyl, heterocyclylalkoxy, aryl, arylalkyl, arylalkoxy, heteroaryl, heteroarylalkyl, heteroarylalkoxy, OH, hydroxyalkyl, halogen, cyano, nitro, amino, alkylamino, alkylaminoalkyl, alkylaminoalkylamino, aminoalkyl, aminoalkylamino, di(alkyl)amino, di(alkyl)aminoalkyl, di(alkyl)aminoalkylamino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, carbamoyl, acyl, alkoxycarbonyl, aminosulfonyl, aminosulfonylalkyl, alkylaminosulfonyl, alkylaminosulfonylalkyl, di(alkyl)aminosulfonyl, di(alkyl)aminosulfonylalkyl, carboxyl, (hydroxyalkyl)carbonyl, trihalo substituted lower alkyl and trihalo substituted lower alkoxy.

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In another aspect of this embodiment, R<sub>1</sub> is selected from the group consisting of aryl optionally substituted with 1 to 5 substituents independently selected from the group consisting of lower alkyl, lower alkoxy, heterocyclyl, heterocyclylalkyl, aryl, arylalkyl, heteroaryl, heteroarylalkyl, OH, halogen, cyano, amino, alkylamino, alkylaminoalkyl, alkylaminoalkylamino, aminoalkyl, aminoalkylamino, di(alkyl)amino, di(alkyl)aminoalkyl, di(alkyl)aminoalkylamino, carbamoyl, acyl, alkoxycarbonyl, aminosulfonyl, aminosulfonylalkyl, alkylaminosulfonyl, alkylaminosulfonylalkyl, di(alkyl)aminosulfonyl, di(alkyl)aminosulfonylalkyl, carboxyl, trihalo

substituted lower alkyl and trihalo substituted lower alkoxy.

Preferably  $R_1$  is selected from the group consisting of phenyl optionally substituted with 1 to 5 substituents independently selected from the group consisting of lower alkyl, lower alkoxy, OH, halogen, cyano, amino, alkylamino, alkylaminoalkyl, alkylaminoalkylamino, aminoalkyl, aminoalkylamino, di(alkyl)amino, di(alkyl)aminoalkyl, di(alkyl)aminoalkylamino, carbamoyl, acyl, alkoxycarbonyl, aminosulfonyl, aminosulfonylalkyl, alkylaminosulfonyl, alkylaminosulfonylalkyl, di(alkyl)aminosulfonyl, di(alkyl)aminosulfonylalkyl, carboxyl, trihalo substituted lower alkyl and trihalo substituted lower alkoxy. In another aspect,  $R_1$  is selected from the group consisting of phenyl optionally substituted with 1 to 5 substituents independently selected from the group consisting of methoxy, chlorine and fluorine. Still further in a preferred aspect of this embodiment, A is selected from the group consisting of  $-N(R_4)(CH_2)_x-$ ,  $-O(CH_2)_x-$ ,  $-S(CH_2)_x-$ ,  $-SO_2(CH_2)_x-$ ,  $-SO_2N(CH_2)_x-$ ,  $-NSO_2(CH_2)_x-$ ,  $-N(R_4)(CH_2)_{1-4}O(CH_2)_x-$  and  $-N(R_4)(CH_2)_{1-4}NH(CH_2)_x-$ ; wherein x is an integer from 0 to 3. In another aspect, A is selected from the group consisting of  $-N(R_4)(CH_2)_x-$ ,  $-O(CH_2)_x-$ ,  $-S(CH_2)_x-$ ,  $-SO_2(CH_2)_x-$ ,  $-SO_2N(CH_2)_x-$ ,  $-NSO_2(CH_2)_x-$ ,  $-N(R_4)(CH_2)_{1-4}O(CH_2)_x-$  and  $-N(R_4)(CH_2)_{1-4}NH(CH_2)_x-$ ; wherein x is an integer from 0 to 1. Alternatively, A is selected from the group consisting of  $-N(R_4)(CH_2)_x-$  and  $-O(CH_2)_x-$ ; wherein x is an integer from 0 to 1.

Preferably,  $R_4$  is selected from the group consisting of H, alkyl, lower alkyl, alkoxyalkyl, alkenyl, lower alkenyl, hydroxyalkyl, aryl, arylalkyl and heteroaryl and still more preferably  $R_4$  is selected from the group consisting of H, lower alkyl and hydroxyalkyl. Most preferably,  $R_4$  is H.

In another aspect of this embodiment,  $R_2$  is selected from the group consisting of heteroaryl and biheteroaryl optionally substituted with 1 to 2 substituents independently selected from  $R_7$  and optionally substituted with 1 substituent selected from  $R_8$ ; wherein  $R_7$  is substituted on the 2 or 6 position from the point of attachment of  $R_2$ ; and, wherein  $R_8$  is substituted on a carbon atom at the 4 or 5 position from the point of attachment of  $R_2$ . Preferably  $R_2$  is selected from the group consisting of heteroaryl optionally substituted with 1



substituent selected from  $R_7$  and substituted with 1 substituent selected from  $R_8$ ; wherein  $R_7$  is substituted on the 2 or 6 position from the point of attachment of  $R_2$ ; and, wherein  $R_8$  is substituted on a carbon atom at the 4 or 5 position from the point of attachment of  $R_2$ .

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In one aspect  $R_2$  is selected from the group consisting of thienyl, pyrrolyl, oxazolyl, thiazolyl, imidazolyl, pyrazolyl, isoxazolyl, isothiazolyl, pyridinyl, pyridazinyl, pyrimidinyl and pyrazinyl optionally substituted with 1 substituent selected from  $R_7$  and substituted with 1 substituent selected from  $R_8$ ; wherein  $R_7$  is substituted on the 2 or 6 position from the point of attachment of  $R_2$ ; and, wherein  $R_8$  is substituted on a carbon atom at the 4 or 5 position from the point of attachment of  $R_2$ . Preferably  $R_2$  is selected from the group consisting of pyridinyl, pyridazinyl, pyrimidinyl and pyrazinyl optionally substituted with 1 substituent selected from  $R_7$  and substituted with 1 substituent selected from  $R_8$ ; wherein  $R_7$  is substituted on the 2 or 6 position from the point of attachment of  $R_2$ ; and, wherein  $R_8$  is substituted on a carbon atom at the 4 or 5 position from the point of attachment of  $R_2$ .

Also preferably  $R_7$  is selected from the group consisting of lower alkyl, lower alkoxy, heterocyclylalkyl, aryl, arylalkyl, OH, hydroxyalkyl, halogen, cyano, nitro, amino, alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, acyl, carboxyl, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy. In a preferred embodiment,  $R_7$  is selected from the group consisting of lower alkyl, OH, halogen, cyano, nitro, amino, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy. In yet another embodiment,  $R_7$  is selected from the group consisting of methyl, ethyl, OH, bromine, chlorine, fluorine, cyano, nitro, amino, trifluoromethyl and trifluoromethoxy.

$R_8$  is preferably selected from the group consisting of OH, amino, (hydroxyalkyl)amino, alkoxycarbonyl,  $\text{OCON}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_n\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{CH}(\text{R}_5)_2$ ,  $\text{NH}(\text{CH}_2)_n\text{SO}_2(\text{CH}_2)_m\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{OCH}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{O}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_n\text{SO}_2\text{NH}(\text{CH}_2)_m\text{R}_5$ ,

- $\text{NH}(\text{CH}_2)_n\text{CH}(\text{OH})(\text{CH}_2)_m\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{CH}(\text{OH})(\text{CH}_2)_m\text{OR}_5$ ,  
 $\text{NH}(\text{CH}_2)_n\text{CH}(\text{OH})(\text{CH}_2)_m\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_n\text{CO}(\text{CH}_2)_m\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ,  
 $\text{NH}(\text{CH}_2)_n\text{CO}_2(\text{CH}_2)_m\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{CO}(\text{CH}_2)_m\text{SO}_2\text{NH}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{R}_5$ ,  
 $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{O}(\text{CH}_2)_m\text{R}_5$ ,  
5  $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{CO}(\text{CH}_2)_m\text{R}_5$ ,  $\text{CONH}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$  and  
 $\text{CONH}(\text{CH}_2)_n\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ; wherein  $n$  is an integer from 0 to 6 and  $m$  is an  
integer from 0 to 4; with the proviso, that  $m$  is at least 1 when  $\text{R}_5$  is selected from  
the group consisting of OH, amino, alkylamino and di(alkyl)amino. In one  
aspect of this embodiment,  $\text{R}_8$  is selected from the group consisting of OH,  
10 amino, (hydroxyalkyl)amino, alkoxy carbonyl,  $\text{OCON}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_n\text{R}_5$ ,  
 $\text{NH}(\text{CH}_2)_n\text{CH}(\text{R}_5)_2$ ,  $\text{NH}(\text{CH}_2)_n\text{SO}_2(\text{CH}_2)_m\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$ ,  
 $\text{NH}(\text{CH}_2)_n\text{OCH}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{O}(\text{CH}_2)_m\text{R}_5$ ,  
 $\text{NH}(\text{CH}_2)_n\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_n\text{SO}_2\text{NH}(\text{CH}_2)_m\text{R}_5$ ,  
 $\text{NH}(\text{CH}_2)_n\text{CH}(\text{OH})(\text{CH}_2)_m\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{CH}(\text{OH})(\text{CH}_2)_m\text{OR}_5$ ,  
15  $\text{NH}(\text{CH}_2)_n\text{CH}(\text{OH})(\text{CH}_2)_m\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_n\text{CO}(\text{CH}_2)_m\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ,  
 $\text{NH}(\text{CH}_2)_n\text{CO}_2(\text{CH}_2)_m\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{CO}(\text{CH}_2)_m\text{SO}_2\text{NH}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{R}_5$ ,  
 $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{O}(\text{CH}_2)_m\text{R}_5$ ,  
 $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{CO}(\text{CH}_2)_m\text{R}_5$ ,  $\text{CONH}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$  and  
 $\text{CONH}(\text{CH}_2)_n\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ; wherein  $n$  is an integer from 0 to 5 and  $m$  is an  
20 integer from 0 to 2; with the proviso, that  $m$  is at least 1 when  $\text{R}_5$  is selected from  
the group consisting of OH, amino, alkylamino and di(alkyl)amino. Still more  
preferably,  $\text{R}_8$  is selected from the group consisting of OH, amino,  
(2-hydroxyethyl)amino, (3-hydroxy-*n*-propyl)amino, (4-hydroxy-*n*-butyl)amino,  
ethoxy carbonyl,  $\text{OCON}(\text{R}_5)_2$ ,  $\text{NH}(\text{CH}_2)_{1-4}\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_{1-3}\text{SO}_2(\text{CH}_2)_{0-1}\text{R}_5$ ,  
25  $\text{NH}(\text{CH}_2)_{1-3}\text{O}(\text{CH}_2)_{0-1}\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_{1-4}\text{OCH}[(\text{CH}_2)_{1-2}\text{R}_5]_2$ ,  
 $\text{NH}(\text{CH}_2)_{1-3}\text{O}(\text{CH}_2)_{1-2}\text{O}(\text{CH}_2)_{1-2}\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_{1-4}\text{N}[(\text{CH}_2)_{0-2}\text{R}_5]_2$ ,  
 $\text{NH}(\text{CH}_2)_{1-4}\text{SO}_2\text{NH}(\text{CH}_2)_{1-2}\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_{1-4}\text{CH}(\text{OH})(\text{CH}_2)_{1-2}\text{R}_5$ ,  
 $\text{NH}(\text{CH}_2)_{1-4}\text{CH}(\text{OH})(\text{CH}_2)_{1-2}\text{OR}_5$ ,  $\text{NH}(\text{CH}_2)_{1-4}\text{CH}(\text{OH})(\text{CH}_2)_{1-2}\text{N}[(\text{CH}_2)_{0-1}\text{R}_5]_2$ ,  
 $\text{NH}(\text{CH}_2)_{1-3}\text{CO}(\text{CH}_2)_{0-1}\text{N}[(\text{CH}_2)_{0-1}\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_{1-3}\text{CO}_2(\text{CH}_2)_{0-1}\text{R}_5$ ,  
30  $\text{NH}(\text{CH}_2)_{1-4}\text{CO}(\text{CH}_2)_{1-2}\text{SO}_2\text{NH}(\text{CH}_2)_{1-2}\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_{0-1}\text{R}_5$ ,  
 $\text{NHCO}(\text{CH}_2)_{1-3}\text{O}(\text{CH}_2)_{0-2}\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_{1-2}\text{O}(\text{CH}_2)_{1-2}\text{O}(\text{CH}_2)_{1-2}\text{R}_5$ ,  
 $\text{NHCO}(\text{CH}_2)_{1-2}\text{O}(\text{CH}_2)_{0-1}\text{CO}(\text{CH}_2)_{1-2}\text{R}_5$ ,  $\text{CONH}(\text{CH}_2)_{1-3}\text{O}(\text{CH}_2)_{0-2}\text{R}_5$  and  
 $\text{CONH}(\text{CH}_2)_{1-3}\text{N}[(\text{CH}_2)_{1-2}\text{R}_5]_2$ ; with the proviso, that the  $\text{R}_5$  alkylene linking  
group is at least methylene when  $\text{R}_5$  is selected from the group consisting of OH,

amino, alkylamino and di(alkyl)amino.

In another embodiment of this invention, R<sub>5</sub> is selected from the group consisting of H, OH, lower alkyl, amino, alkylamino, di(alkyl)amino, aryl, heteroaryl and heterocyclyl; wherein aryl, heteroaryl and heterocyclyl are optionally substituted with 1 to 3 substituents independently selected from the group consisting of lower alkyl, acyl, carboxyl, aryl (optionally substituted with one halogen substituent), di(alkyl)amino; alkylsulfonyl, aminosulfonyl, alkylaminosulfonyl and aminosulfonylalkyl; and, wherein heterocyclyl is further optionally substituted with 1 to 3 oxo substituents. Preferably R<sub>5</sub> is selected from the group consisting of H, OH, lower alkyl, heteroaryl and heterocyclyl; wherein heterocyclyl is optionally substituted with 1 to 3 substituents independently selected from the group consisting of lower alkyl, acyl, carboxyl, aryl (optionally substituted with one halogen substituent), di(alkyl)amino, alkylsulfonyl, aminosulfonyl, alkylaminosulfonyl, aminosulfonylalkyl and oxo. In a preferred embodiment, R<sub>5</sub> is selected from the group consisting of H, OH, methyl, ethyl, *t*-butyl, 1*H*-azetidiny, 1*H*-pyrrolidinyl, 4-tetrahydro-2*H*-pyranyl, hexahydro-1*H*-azepiny, 1,3-dioxolanyl, 1,3-dioxanyl, piperidinyl, piperazinyl, imidazolyl, pyrazolyl, triazolyl and pyridinyl; wherein 1,3-dioxolanyl, 1,3-dioxanyl, piperazinyl and piperidinyl are optionally substituted with 1 to 2 substituents independently selected from the group consisting of methyl, acetyl, carboxyl, phenyl (optionally substituted with chlorine), di(methyl)amino, methylsulfonyl, methylaminosulfonyl and oxo.

In other embodiments, R<sub>3</sub> is selected from the group consisting of H, lower alkyl, lower alkoxy, OH, halogen, cyano, amino, alkylamino and di(alkyl)amino. Preferably, R<sub>3</sub> is selected from the group consisting of H, lower alkyl, lower alkoxy, OH, halogen, amino and di(alkyl)amino and more preferably, R<sub>3</sub> is selected from the group consisting of H and methyl.

Preferred compounds include:

3-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-propanol;  
3-[[5-[2-[(3-chlorophenyl)amino]-6-methyl-4-pyrimidinyl]-3-pyridinyl]amino]-1-propanol;

2-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]-ethanol;  
4-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-butanol;  
3-[[5-[6-[(3-fluorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-propanol;  
3-[[5-[6-[(3-methoxyphenyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-propanol;  
3-[[5-[6-[(phenylmethyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-propanol;  
3-[[6'-[(3-chlorophenyl)amino][2,2'-bipyrazin]-6-yl]amino]-1-propanol;  
3-[[4-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-propanol;  
3-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-2-thiazolyl]amino]-1-propanol;  
and,  
2-[2-[2-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]ethoxy]ethoxy]-ethanol.

Additional preferred compounds include:

6-(5-amino-3-pyridinyl)-*N*-(3-chlorophenyl)-2-pyrazinamine;  
*N*<sup>1</sup>-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-*N*<sup>2</sup>,*N*<sup>2</sup>-dimethyl-1,2-ethanediamine;  
*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-4-morpholinepropanamine;  
*N*<sup>1</sup>-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-*N*<sup>3</sup>,*N*<sup>3</sup>-dimethyl-1,3-propanediamine;  
*N*-(3-chlorophenyl)-6-[5-[[3-(1-piperazinyl)propyl]amino]-3-pyridinyl]-2-pyrazinamine;  
*N*-(3-chlorophenyl)-6-[5-[[4-(4-pyridinyl)butyl]amino]-3-pyridinyl]-2-pyrazinamine;  
*N*-(3-chlorophenyl)-6-[5-[[3-(4-pyridinyl)propyl]amino]-3-pyridinyl]-2-pyrazinamine;  
*N*-(3-chlorophenyl)-6-[5-[[3-(3-pyridinyl)propyl]amino]-3-pyridinyl]-2-pyrazinamine;  
*N*-(3-chlorophenyl)-6-[5-[[3-(1*H*-pyrazol-1-yl)propyl]amino]-3-pyridinyl]-2-pyrazinamine;  
*N*-(3-chlorophenyl)-6-[5-[[3-(1*H*-1,2,4-triazol-1-yl)propyl]amino]-3-pyridinyl]-2-pyrazinamine;  
*N*-(3-chlorophenyl)-6-[5-[[3-(1*H*-imidazol-1-yl)propyl]amino]-3-pyridinyl]-2-pyrazinamine;  
*N*-(3-chlorophenyl)-6-[5-[[3-(tetrahydro-2*H*-pyran-4-yl)methyl]amino]-3-pyridinyl]-2-pyrazinamine;  
*N*-(3-chlorophenyl)-6-[5-[[2-(2-methoxyethoxy)ethyl]amino]-3-pyridinyl]-2-pyrazinamine;  
*N*-(4-methoxyphenyl)-6-[5-[[3-(4-pyridinyl)propyl]amino]-3-pyridinyl]-2-pyrazinamine;  
*N*-(3,4-dichlorophenyl)-6-[5-[[3-(4-pyridinyl)propyl]amino]-3-pyridinyl]-2-pyrazinamine;  
*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-2-(2-methoxyethoxy)-acetamide;

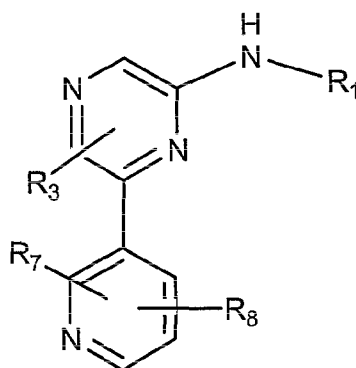
*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-2-ethoxy-acetamide;  
*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-3-methoxy-propanamide;  
 and,  
*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-2-hydroxy-acetamide.

Further preferred compounds include:

*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-2-methoxy-acetamide;  
*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-3-pyridinecarboxamide;  
*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-1-pyrrolidinecarboxamide;  
 and,  
 4-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]-butanoic acid ethyl ester.

In another aspect of the invention, the invention relates to compounds of

5 Formula 2:



Formula 2

or a pharmaceutically acceptable salt thereof, wherein

- 10 R<sub>1</sub> is selected from the group consisting of cycloalkyl, heterocyclyl, biheterocyclyl, aryl, biaryl, heteroaryl and biheteroaryl optionally substituted with 1 to 5 substituents independently selected from the group consisting of alkyl, lower alkyl, alkenyl, alkynyl, alkoxy, lower alkoxy, heterocyclyl, heterocyclylalkyl, heterocyclylalkenyl, heterocyclylalkynyl, heterocyclylalkoxy, aryl, arylalkyl, arylalkenyl, arylalkynyl, arylalkoxy, heteroaryl, heteroarylalkyl, heteroarylalkenyl, heteroarylalkynyl, heteroarylalkoxy, OH, hydroxyalkyl, halogen, cyano, nitro, amino, alkylamino, alkylaminoalkyl, alkylaminoalkylamino, aminoalkyl, aminoalkylamino, di(alkyl)amino, di(alkyl)aminoalkyl,
- 15

di(alkyl)aminoalkylamino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, carbamoyl, acyl, acylalkyl, alkoxycarbonyl, alkoxycarbonylalkyl, acylamino, alkylsulfonyl, alkylsulfonylamino, arylsulfonylamino (wherein aryl is substituted with 1 to 3 substituents independently selected from the group consisting of cyano, halogen, hydroxy, nitro, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy), aminosulfonyl, aminosulfonylalkyl, alkylaminosulfonyl, alkylaminosulfonylalkyl, di(alkyl)aminosulfonyl, di(alkyl)aminosulfonylalkyl, carboxyl, (hydroxyalkyl)carbonyl, (hydroxyalkoxy)carbonyl, trihalo substituted lower alkyl and trihalo substituted lower alkoxy;

$R_7$  is selected from the group consisting of alkyl, lower alkyl, alkoxy, lower alkoxy, alkenyl, alkynyl, heterocyclyl, heterocyclylalkyl, heterocyclylalkoxy, aryl, arylalkyl, arylalkoxy, OH, hydroxyalkyl, halogen, cyano, nitro, amino, alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, carbamoyl, acyl, acylalkyl, alkoxycarbonyl, alkoxycarbonylalkyl, acylamino, alkylsulfonyl, alkylsulfonylamino, arylsulfonylamino (wherein aryl is substituted with 1 to 3 substituents independently selected from the group consisting of cyano, halogen, hydroxy, nitro, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy), carboxyl, (hydroxyalkyl)carbonyl, (hydroxyalkoxy)carbonyl, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy;

$R_8$  is selected from the group consisting of alkyl, OH, hydroxyalkyl, halogen, cyano, amino, alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, carbamoyl, alkylcarbonylamino, alkylcarbonyl, alkoxycarbonyl, (hydroxyalkyl)carbonyl, (hydroxyalkoxy)carbonyl,  $O(CH_2)_nR_5$ ,  $O(CH_2)_nO(CH_2)_mR_5$ ,  $O(CH_2)_nCH[(CH_2)_mR_5]_2$ ,  $O(CH_2)_nN[(CH_2)_mR_5]_2$ ,  $OCON[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nR_5$ ,  $NH(CH_2)_nCH(R_5)_2$ ,  $NH(CH_2)_nSO_2(CH_2)_mR_5$ ,  $NH(CH_2)_nO(CH_2)_mR_5$ ,  $NH(CH_2)_nOCH[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nO(CH_2)_mO(CH_2)_mR_5$ ,  $NH(CH_2)_nN[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nSO_2NH(CH_2)_mR_5$ ,  $NH(CH_2)_nCH(OH)(CH_2)_mR_5$ ,  $NH(CH_2)_nCH(OH)(CH_2)_mOR_5$ ,  $NH(CH_2)_nCH(OH)(CH_2)_mN[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nCO(CH_2)_mN[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nCO_2(CH_2)_mR_5$ ,

$\text{NH}(\text{CH}_2)_n\text{CO}(\text{CH}_2)_m\text{SO}_2\text{NH}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{CH}(\text{R}_5)_2$ ,  
 $\text{NHCO}(\text{CH}_2)_n\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$ ,  
 $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{O}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{CO}(\text{CH}_2)_m\text{R}_5$ ,  
 $\text{NHCO}(\text{CH}_2)_n\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{CONH}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$ , and

- 5  $\text{CONH}(\text{CH}_2)_n\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ; wherein n is an integer from 0 to 6 and m is an integer from 0 to 4; with the proviso, that m is at least 1 when  $\text{R}_5$  is selected from the group consisting of OH, amino, alkylamino and di(alkyl)amino;

- $\text{R}_5$  is selected from the group consisting of H, OH, lower alkyl, amino,  
 10 alkylamino, di(alkyl)amino, aryl, heteroaryl, biheteroaryl and heterocyclyl;  
 wherein aryl, heteroaryl and heterocyclyl are optionally substituted with 1 to 3 substituents independently selected from the group consisting of alkyl, lower alkyl, acyl, carboxyl, aryl (optionally substituted with 1 to 5 halogen substituents), OH, halogen, cyano, amino, alkylamino, di(alkyl)amino,  
 15 (hydroxyalkyl)amino, di(hydroxyalkyl)amino, alkylsulfonyl, aminosulfonyl, alkylaminosulfonyl and aminosulfonylalkyl; and, wherein heterocyclyl is further optionally substituted with 1 to 3 oxo substituents; and,

- $\text{R}_3$  is selected from the group consisting of H, alkyl, lower alkyl, alkoxy, lower  
 20 alkoxy, alkenyl, alkynyl, heterocyclyl, heterocyclylalkyl, heterocyclylalkoxy, aryl, arylalkyl, arylalkoxy, OH, hydroxyalkyl, halogen, cyano, nitro, amino, alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, carbamoyl, acyl, acylalkyl, alkoxycarbonyl, alkoxycarbonylalkyl, acylamino, alkylsulfonyl, alkylsulfonylamino, arylsulfonylamino (wherein aryl is  
 25 substituted with 1 to 3 substituents independently selected from the group consisting of cyano, halogen, hydroxy, nitro, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy), carboxyl, (hydroxyalkyl)carbonyl, (hydroxyalkoxy)carbonyl, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy.

30

In a preferred embodiment of this invention, the compounds are provided as pharmaceutical compositions comprising a pharmaceutically acceptable carrier.

The invention further relates to a method for inhibiting the vascular endothelial growth factor (VEGF) receptor tyrosine kinase comprising the step of administering a therapeutically effective amount of the compounds of this invention. In a preferred embodiment, the method is used to treat a disease  
5 selected from the group consisting of aberrant angiogenesis, tumors, diabetic retinopathy, rheumatoid arthritis, endometriosis and psoriasis.

The invention also relates to a method of treating angiogenesis in a subject in need thereof comprising administering a therapeutically effective  
10 amount of the compounds of this invention. Methods for treating tumors, including solid-tumors is also contemplated in this invention. The invention also relates to methods of treating diabetic retinopathy in a subject in need thereof comprising administering a therapeutically effective amount of a compound of this invention. Further methods for treating rheumatoid arthritis, psoriasis and  
15 endometriosis in a subject in need thereof comprising administering a therapeutically effective amount of the compound of claim 1.

In a further method of this invention, the invention relates to a method of inhibiting the vascular endothelial growth factor (VEGF) receptor tyrosine  
20 kinase comprising the step of administering a composition of this invention. Preferred diseases associated with this method include aberrant angiogenesis, tumors, diabetic retinopathy, rheumatoid arthritis, endometriosis and psoriasis.

The compounds of the present invention are useful in treating conditions  
25 mediated by the activity of the VEGF-R including, but not limited to, solid-tumor cancers, angiogenesis, diabetic retinopathy, rheumatoid arthritis, endometriosis and psoriasis.

#### BRIEF DESCRIPTION OF THE DRAWINGS

30

Figure 1: A375 cell line tumor growth delay by compound 33. Black square represents control samples; Open triangle represents compound 33 used at 50mg/Kg; Open circle represents compound 33 used at 5 mg/Kg.



## DETAILED DESCRIPTION

Definitions

Unless specified otherwise, the term "alkyl" refers to a saturated straight, branched or cyclic substituent consisting solely of carbon and H containing 1 to 5 10 carbon atoms for a carbon chain and 3 to 8 carbon atoms for a cyclic substituent; preferably, 1 to 8 carbon atoms for a carbon chain and 4 to 7 carbon atoms for a cyclic substituent; and, most preferably, 1 to 6 carbon atoms for a carbon chain and 5 to 6 carbon atoms for a cyclic substituent. The term "lower alkyl" refers to an alkyl chain substituent containing 1 to 4 carbon atoms; 10 preferably, 1 to 2 carbon atoms, where alkyl is defined *supra*. The term "alkenyl" refers to an unsaturated straight, branched or cyclic substituent consisting solely of carbon and H atoms containing at least one double bond. The term "alkynyl" refers to an unsaturated straight, branched or cyclic substituent consisting solely of carbon and H atoms containing at least one triple 15 bond. The term "alkoxy" refers to O-alkyl where alkyl is as defined *supra*. The term "alkthio" refers to S-alkyl where alkyl is as defined *supra*. The term "carboxyl" refers to an acidic alkyl carbon chain with a terminal COOH group. The term "acyl" refers to a carbonyl linking group -C(=O)- with a terminal alkyl chain, wherein alkyl is as defined *supra*. The terms "alkylamino," 20 "di(alkyl)amino," "(hydroxyalkyl)amino" and "di(hydroxyalkyl)amino" refer to a nitrogen heteroatom linking group with a terminal alkyl chain or chains (substituted or unsubstituted on the terminal carbon with hydroxy). Alkyl, alkenyl, alkynyl and alkoxy carbon chains are substituted, unless indicated otherwise, on the terminal carbon atom of the chain.

25

The term "cycloalkyl" refers to alkyl, alkenyl and alkynyl cyclic ring systems as defined *supra*. The term "heterocyclyl" refers to saturated or partially saturated ring systems containing 4 to 7 ring atoms wherein at least 1 to 3 atoms are independently N, S, or O atoms and the remaining ring atoms are C and H. 30 The term "biheterocyclyl" refers to bicyclic saturated or partially saturated ring systems containing 9 to 12 ring atoms wherein at least 1 to 3 atoms are independently N, S, or O atoms and the remaining ring atoms are C and H and includes bicyclic ring systems comprising a heterocyclyl ring fused to a benzene ring. Embodiments for compounds of the present invention include those

wherein heterocyclyl are selected from 2*H*-pyrrole, pyrrolinyl (selected from 2-pyrrolinyl, 3-pyrrolinyl), pyrrolidinyl, dioxlanyl, 2-imidazoliny, imidazolidinyl, 2-pyrazoliny, pyrazolidinyl, 2*H*-pyranyl, 4*H*-pyranyl, piperidinyl, dioxolanyl, morpholinyl, dithianyl, thiomorpholinyl and piperazinyl.

- 5 The term "cycloalkylalkyl" and "heterocyclylalkyl" refers to an alkyl chain substituted on the terminal carbon atom with a cycloalkyl and heterocyclyl group, respectively; where alkyl, cycloalkyl and heterocyclyl are as defined *supra*.

- 10 The term "aryl" refers to aromatic ring systems containing 5 to 10 carbon atoms and H. The term "biaryl" refers to bicyclic aromatic ring systems containing 9 to 12 carbon atoms and H. The term "arylalkyl" and "biarylalkyl" refers to an alkyl chain substituted on the terminal carbon atom with an aryl and biaryl group, respectively; where alkyl, aryl and biaryl are as defined *supra*.
- 15 Embodiments for compounds of the present invention include those wherein aryl and biaryl are selected from phenyl and naphthalenyl.

- The term "heteroaryl" refers to aromatic ring systems containing 5 to 7 ring atoms wherein at least 1 to 3 atoms are independently N, S, or O atoms and the remaining ring atoms are C and H. The term "biheteroaryl" refers to bicyclic aromatic ring systems containing 9 to 12 ring atoms wherein at least 1 to 4 atoms are independently N, S, or O atoms and the remaining ring atoms are C and H. Embodiments for compounds of the present invention include those wherein heteroaryl and biheteroaryl are selected from furyl, thienyl, pyrrolyl, oxazolyl, 20 thiazolyl, imidazolyl, pyrazolyl, isoxazolyl, isothiazolyl, oxadiazolyl, triazolyl, thiadiazolyl, pyridinyl, pyridazinyl, pyrimidinyl, pyrazinyl, triazinyl, indoliziny, indolyl, isoindolyl, benzo[b]furyl, benzo[b]thiophenyl, 1*H*-indazolyl, benzimidazolyl, benzthiazolyl, quinolinyl, isoquinolinyl and quinazolinyl. The term "heteroarylalkyl" and "biheteroarylalkyl" refers to an alkyl chain substituted 25 on the terminal carbon atom with a heteroaryl and biheteroaryl group, respectively; where alkyl, heteroaryl and biheteroaryl are as defined *supra*.
- 30

The term "halo" or "halogen" means fluoro, chloro, bromo and iodo. "Independently" means that when there is more than one substituent that the

substituents may be the same or different. When a group is "substituted", that group may have one or more substituents, preferably from one to five, more preferably one to three, and most preferably at least one substituent independently selected from the list of substituents provided for the group.

5

### Abbreviations

	"Ph" or "PH"	Phenyl
	"Boc"	<i>t</i> -Butoxycarbonyl
	"Cbz"	benzyloxycarbonyl
10	"Ts"	Toluenesulfonyl
	"Fmoc"	<i>N</i> -(9-fluorenylmethoxycarbonyl)
	"P( <i>o</i> -tol) <sub>3</sub> "	Tri- <i>o</i> -tolylphosphine
	"PdCl <sub>2</sub> (PPh <sub>3</sub> ) <sub>2</sub> "	Dichlorobis(triphenylphosphine)palladium(II)
	"Pd <sub>2</sub> (dba) <sub>3</sub> "	Tris(dibenzylideneacetone)-dipalladium(0)
15	"Pd <sub>2</sub> (dba) <sub>3</sub> " adduct	Tris(dibenzylideneacetone)dipalladium(0)-chloroform adduct
	"DMAP"	4-(dimethylamino)pyridine
	"DPPF"	1,1'-Bis(diphenylphosphino)-ferrocene
	"DPPA"	Diphenylphosphoryl azide
20	"OTf"	Trifluorosulfonyloxy
	"OTBS"	<i>t</i> -Butyldimethylsilyloxy
	"OTBDMS"	<i>t</i> -Butyldimethylsilyloxy
	"TFA"	Trifluoroacetic acid
	triflate	Trifluorosulfonyloxy
25	"AsPPh <sub>3</sub> "	Triphenylarsine
	"EDCI"	1-(3-Dimethylaminopropyl)-3-ethylcarbodiimide
	"TMEDA"	Tetramethylethylenediamine
	"HATU"	<i>o</i> -(7-Azabenzotriazol-1-yl)-1,1,3,3-tetramethyluronium
	"BINAP"	2,2'-Bis(diphenylphosphino)-1,1'-binaphthyl
30	"Pd(OAc) <sub>2</sub> "	Palladium acetate
	"DMAP"	Dimethylaminopyridine
	"NMP"	1-Methyl-2-pyrrolidinone
	"Cnd"	Compound
	"THF"	Tetrahydrofuran
35	"CDI"	Carbonyl diimidazolyl

The term "subject" includes, without limitation, any animal or artificially modified animal. In a preferred embodiment, the subject is a human.

The compounds of the present invention may also be present in the form of pharmaceutically acceptable salts. For use in medicine, the salts of the compounds of this invention refer to non-toxic "pharmaceutically acceptable salts" (*Ref. International J. Pharm.*, **1986**, *33*, 201-217; *J. Pharm.Sci.*, **1997** 5 (Jan), *66*, *1*, 1). Other salts may, however, be useful in the preparation of compounds according to this invention or of their pharmaceutically acceptable salts. Representative organic or inorganic acids include, but are not limited to, hydrochloric, hydrobromic, hydriodic, perchloric, sulfuric, nitric, phosphoric, acetic, propionic, glycolic, lactic, succinic, maleic, fumaric, malic, tartaric, citric, 10 benzoic, mandelic, methanesulfonic, hydroxyethanesulfonic, benzenesulfonic, oxalic, pamoic, 2-naphthalenesulfonic, *p*-toluenesulfonic, cyclohexanesulfamic, salicylic, saccharinic or trifluoroacetic acid. Representative organic or inorganic bases include, but are not limited to, basic or cationic salts such as benzathine, chlorprocaine, choline, diethanolamine, ethylenediamine, meglumine, procaine, 15 aluminum, calcium, lithium, magnesium, potassium, sodium and zinc.

To the extent that certain compounds of the present invention may have at least one chiral center, the compounds may thus exist as enantiomers. In addition, the compounds of the present invention may also possess two or more 20 chiral centers and thus may also exist as diastereomers or as exo or endo isomers. Where the processes for the preparation of the present compounds give rise to a mixture of stereoisomers, these isomers may be separated by conventional techniques such as preparative chromatography. Accordingly, the compounds may be prepared as a racemic mixture or, by either enantiospecific synthesis or 25 resolution, as individual enantiomers. The compounds may, for example, be resolved from a racemic mixture into their component racemates by standard techniques, such as the formation of diastereomeric pairs by salt formation with an optically active acid, such as (-)-di-*p*-toluoyl-*d*-tartaric acid and/or (+)-di-*p*-toluoyl-*l*-tartaric acid followed by fractional crystallization and regeneration of 30 the free base. The racemic mixture may also be resolved by formation of diastereomeric esters or amides, followed by chromatographic separation and removal of the chiral auxiliary. Alternatively, the compounds may be resolved using a chiral HPLC column. It is to be understood that all such isomers and mixtures thereof are encompassed within the scope of the present invention.

During any of the processes for preparation of the compounds of the present invention, it may be necessary and/or desirable to protect sensitive or reactive groups on any of the molecules concerned. This may be achieved by means of conventional protecting groups, such as those described in Protective Groups in Organic Chemistry, ed. J.F.W. McOmie, Plenum Press, 1973; and T.W. Greene & P.G.M. Wuts, Protective Groups in Organic Synthesis, John Wiley & Sons, 1991. The protecting groups may be removed at a convenient subsequent stage using methods known from the art.

Furthermore, some of the crystalline forms for the compounds may exist as polymorphs and as such are intended to be included in the present invention. In addition, some of the compounds may form solvates with water (i.e., hydrates) or common organic solvents, and such solvates are also intended to be encompassed within the scope of this invention.

The present invention includes compounds that are useful in the treatment of diseases associated with the stimulation and presentation of inappropriate, abnormal or increased angiogenesis; for example excessive angiogenesis that is associated with some proliferative diseases or disease states including, but not limited to diabetic retinopathy, rheumatoid arthritis, endometriosis and psoriasis.

Inappropriate or aberrant angiogenesis is also associated with cancer, and in particular, cancers associated with foci of proliferating cells. For purposes of this invention the term "cancer" refers to angiogenesis associated with uncontrolled cell proliferation. Cancers can be benign or malignant and refers to any group for cells that have lost their normal regulatory controls that would otherwise govern the rate of cell growth. Some cancer cells stimulate ingrowth of the vasculature, also referred to as neovascularization, to facilitate survival. Neovascularization further facilitates metastasis. The cancer cells spread throughout the body and invade normal tissues where they proliferate and form secondary cancers. These masses of cancer cells are also referred to as tumors. Tumors, and in particular, solid tumors, require the process of

angiogenesis to supply oxygen and nutrients. Without a blood supply a tumor can only grow to the size of a few millimeters. Angiogenesis inhibitors inhibit neovascularization and are therefore effective inhibit cancer cell growth in a variety of cancers that require the ingrowth of the microvasculature. Such tumors include for example, breast cancers, pancreatic cancer, skin cancers, including melanomas and basal cell carcinomas, a variety of cancers of the lung, prostate cancers, ovarian cancers, brain cancers, liver cancers, renal and hepatic cancers, uterine cancers, cancers of the gastrointestinal system, colorectal cancers, cancers of the head and neck, including cancers of the mouth and throat,

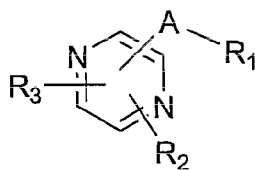
In these diseases, aberrant angiogenesis can be controlled through the use of angiogenesis inhibitors. These inhibitors are molecules that bind to cell receptors, generally on endothelial cells, that are known to be associated with the formation of neovasculature and inhibit receptor signalling pathways resulting in an inhibition of neovascularization. Such receptors include the Vascular Endothelial Growth Factors, such as VEGF-1, 2, 3 and others described below that have been implicated in angiogenesis.

#### Pyrazine Derivative Compounds

Certain pyrazine compounds, described herein, are useful as tyrosine kinase inhibitors, particularly as inhibitors of the kinase domain of VEGF-R (Vascular endothelial growth factor receptor-2, Genbank Accession number X61656), EGFR (epidermal growth factor receptor), GSK-3 $\beta$  (glycogen synthase kinase-3 beta subunit), PDGF-R (platelet derived growth factor receptor), and FGF-R2 (fibroblast growth factor receptor-2). Preferably, compounds of the present invention are selective inhibitors of the VEGF-R.

Useful inhibitory activity is defined herein as an IC<sub>50</sub> of less than 10  $\mu$ M (10 micromolar); preferably, inhibitory activity is less than or equal to 5  $\mu$ M; and, more preferably, inhibitory activity is less than or equal to 1  $\mu$ M. Using methods well known in the art and/or using the methods provided in the example *infra*, compounds of the present invention may be tested for their ability to inhibit the enzymatic activity of other kinases.

The present invention provides novel compounds of Formula 1:



Formula 1

or a pharmaceutically acceptable salt thereof, wherein

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$R_1$  is selected from the group consisting of cycloalkyl, heterocyclyl, biheterocyclyl, aryl, biaryl, heteroaryl and biheteroaryl optionally substituted with 1 to 5 substituents independently selected from the group consisting of alkyl, lower alkyl, alkenyl, alkynyl, alkoxy, lower alkoxy, heterocyclyl, heterocyclylalkyl, heterocyclylalkenyl, heterocyclylalkynyl, heterocyclylalkoxy, aryl, arylalkyl, arylalkenyl, arylalkynyl, arylalkoxy, heteroaryl, heteroarylalkyl, heteroarylalkenyl, heteroarylalkynyl, heteroarylalkoxy, OH, hydroxyalkyl, halogen, cyano, nitro, amino, alkylamino, alkylaminoalkyl, alkylaminoalkylamino, aminoalkyl, aminoalkylamino, di(alkyl)amino, di(alkyl)aminoalkyl, di(alkyl)aminoalkylamino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, carbamoyl, acyl, acylalkyl, alkoxycarbonyl, alkoxycarbonylalkyl, acylamino, alkylsulfonyl, alkylsulfonylamino, arylsulfonylamino (wherein aryl is substituted with 1 to 3 substituents independently selected from the group consisting of cyano, halogen, hydroxy, nitro, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy), aminosulfonyl, aminosulfonylalkyl, alkylaminosulfonyl, alkylaminosulfonylalkyl, di(alkyl)aminosulfonyl, di(alkyl)aminosulfonylalkyl, carboxyl, (hydroxyalkyl)carbonyl, (hydroxyalkoxy)carbonyl, trihalo substituted lower alkyl and trihalo substituted lower alkoxy;

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A is selected from the group consisting of  $-N(R_4)(CH_2)_x-$ ,  $-O(CH_2)_x-$ ,  $-S(CH_2)_x-$ ,  $-SO_2(CH_2)_x-$ ,  $-SO_2N(CH_2)_x-$ ,  $-NSO_2(CH_2)_x-$ ,  $-N(R_4)(CH_2)_{1-4}O(CH_2)_x-$ ,  $-N(R_4)(CH_2)_{1-4}NH(CH_2)_x-$ ,  $-N(R_4)CONH(CH_2)_x-$  and  $-N(R_4)CNNH(CH_2)_x-$ ; wherein x is an integer from 0 to 4;

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- $R_4$  is selected from the group consisting of H, lower alkyl, alkyl, hydroxyalkyl, alkoxyalkyl, arylalkyl, lower alkenyl, alkenyl, aryl and heteroaryl; wherein aryl and heteroaryl are optionally substituted with 1 to 5 substituents independently selected from the group consisting of OH, halogen, cyano, nitro, amino, alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, alkyl, lower alkyl, alkoxy, lower alkoxy, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy;
- $R_2$  is selected from the group consisting of heteroaryl and biheteroaryl optionally substituted with 1 to 2 substituents independently selected from  $R_7$  and 1 substituent selected from  $R_8$ ;
- $R_7$  is selected from the group consisting of alkyl, lower alkyl, alkoxy, lower alkoxy, alkenyl, alkynyl, heterocyclyl, heterocyclylalkyl, heterocyclylalkoxy, aryl, arylalkyl, arylalkoxy, OH, hydroxyalkyl, halogen, cyano, nitro, amino, alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, carbamoyl, acyl, acylalkyl, alkoxycarbonyl, alkoxycarbonylalkyl, acylamino, alkylsulfonyl, alkylsulfonylamino, arylsulfonylamino (wherein aryl is substituted with 1 to 3 substituents independently selected from the group consisting of cyano, halogen, hydroxy, nitro, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy), carboxyl, (hydroxyalkyl)carbonyl, (hydroxyalkoxy)carbonyl, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy;
- $R_8$  is selected from the group consisting of alkyl, OH, hydroxyalkyl, halogen, cyano, amino, alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, carbamoyl, alkylcarbonylamino, alkylcarbonyl, alkoxycarbonyl, (hydroxyalkyl)carbonyl, (hydroxyalkoxy)carbonyl,  $O(CH_2)_nR_5$ ,  $O(CH_2)_nO(CH_2)_mR_5$ ,  $O(CH_2)_nCH[(CH_2)_mR_5]_2$ ,  $O(CH_2)_nN[(CH_2)_mR_5]_2$ ,  $OCON[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nR_5$ ,  $NH(CH_2)_nCH(R_5)_2$ ,  $NH(CH_2)_nSO_2(CH_2)_mR_5$ ,  $NH(CH_2)_nO(CH_2)_mR_5$ ,  $NH(CH_2)_nOCH[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nO(CH_2)_mO(CH_2)_mR_5$ ,  $NH(CH_2)_nN[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nSO_2NH(CH_2)_mR_5$ ,  $NH(CH_2)_nCH(OH)(CH_2)_mR_5$ ,  $NH(CH_2)_nCH(OH)(CH_2)_mOR_5$ ,  $NH(CH_2)_nCH(OH)(CH_2)_mN[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nCO(CH_2)_mN[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nCO_2(CH_2)_mR_5$ ,



$\text{NH}(\text{CH}_2)_n\text{CO}(\text{CH}_2)_m\text{SO}_2\text{NH}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{CH}(\text{R}_5)_2$ ,  
 $\text{NHCO}(\text{CH}_2)_n\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$ ,  
 $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{O}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{CO}(\text{CH}_2)_m\text{R}_5$ ,  
 $\text{NHCO}(\text{CH}_2)_n\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{CONH}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$ , and

- 5  $\text{CONH}(\text{CH}_2)_n\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ; wherein n is an integer from 0 to 6 and m is an integer from 0 to 4; with the proviso, that m is at least 1 when  $\text{R}_5$  is selected from the group consisting of OH, amino, alkylamino and di(alkyl)amino;

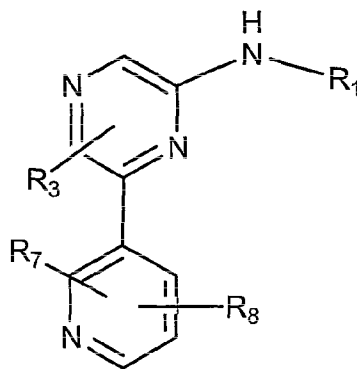
- $\text{R}_5$  is selected from the group consisting of H, OH, lower alkyl, amino,  
 10 alkylamino, di(alkyl)amino, aryl, heteroaryl, biheteroaryl and heterocyclyl;  
 wherein aryl, heteroaryl and heterocyclyl are optionally substituted with 1 to 3 substituents independently selected from the group consisting of alkyl, lower alkyl, acyl, carboxyl, aryl (optionally substituted with 1 to 5 halogen substituents), OH, halogen, cyano, amino, alkylamino, di(alkyl)amino,  
 15 (hydroxyalkyl)amino, di(hydroxyalkyl)amino, alkylsulfonyl, aminosulfonyl, alkylaminosulfonyl and aminosulfonylalkyl; and, wherein heterocyclyl is further optionally substituted with 1 to 3 oxo substituents;

- $\text{R}_3$  is selected from the group consisting of H, alkyl, lower alkyl, alkoxy, lower  
 20 alkoxy, alkenyl, alkynyl, heterocyclyl, heterocyclylalkyl, heterocyclylalkoxy, aryl, arylalkyl, arylalkoxy, OH, hydroxyalkyl, halogen, cyano, nitro, amino, alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, carbamoyl, acyl, acylalkyl, alkoxycarbonyl, alkoxycarbonylalkyl, acylamino, alkylsulfonyl, alkylsulfonylamino, arylsulfonylamino (wherein aryl is  
 25 substituted with 1 to 3 substituents independently selected from the group consisting of cyano, halogen, hydroxy, nitro, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy), carboxyl, (hydroxyalkyl)carbonyl, (hydroxyalkoxy)carbonyl, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy.

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Preferred embodiments for compounds of the present invention include compounds of Formula 1 selected from a compound of Formula 2:

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Formula 2

wherein all variables are as defined previously.

5           Embodiments for compounds of the present invention include compounds of Formula 1 wherein R<sub>1</sub> is selected from the group consisting of cycloalkyl, heterocyclyl, biheterocyclyl, aryl, biaryl, heteroaryl and biheteroaryl optionally substituted with 1 to 5 substituents independently selected from the group consisting of alkyl, lower alkyl, alkenyl, alkynyl, alkoxy, lower alkoxy,  
 10   heterocyclyl, heterocyclylalkyl, heterocyclylalkoxy, aryl, arylalkyl, arylalkoxy, heteroaryl, heteroarylalkyl, heteroarylalkoxy, OH, hydroxyalkyl, halogen, cyano, nitro, amino, alkylamino, alkylaminoalkyl, alkylaminoalkylamino, aminoalkyl, aminoalkylamino, di(alkyl)amino, di(alkyl)aminoalkyl, di(alkyl)aminoalkylamino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino,  
 15   carbamoyl, acyl, alkoxycarbonyl, aminosulfonyl, aminosulfonylalkyl, alkylaminosulfonyl, alkylaminosulfonylalkyl, di(alkyl)aminosulfonyl, di(alkyl)aminosulfonylalkyl, carboxyl, (hydroxyalkyl)carbonyl, trihalo substituted lower alkyl and trihalo substituted lower alkoxy.

20           Preferably, R<sub>1</sub> is selected from the group consisting of aryl optionally substituted with 1 to 5 substituents independently selected from the group consisting of lower alkyl, lower alkoxy, heterocyclyl, heterocyclylalkyl, aryl, arylalkyl, heteroaryl, heteroarylalkyl, OH, halogen, cyano, amino, alkylamino, alkylaminoalkyl, alkylaminoalkylamino, aminoalkyl, aminoalkylamino,  
 25   di(alkyl)amino, di(alkyl)aminoalkyl, di(alkyl)aminoalkylamino, carbamoyl, acyl, alkoxycarbonyl, aminosulfonyl, aminosulfonylalkyl, alkylaminosulfonyl, alkylaminosulfonylalkyl, di(alkyl)aminosulfonyl, di(alkyl)aminosulfonylalkyl,

carboxyl, trihalo substituted lower alkyl and trihalo substituted lower alkoxy.

More preferably,  $R_1$  is selected from the group consisting of phenyl optionally substituted with 1 to 5 substituents independently selected from the group consisting of lower alkyl, lower alkoxy, OH, halogen, cyano, amino, alkylamino, alkylaminoalkyl, alkylaminoalkylamino, aminoalkyl, aminoalkylamino, di(alkyl)amino, di(alkyl)aminoalkyl, di(alkyl)aminoalkylamino, carbamoyl, acyl, alkoxycarbonyl, aminosulfonyl, aminosulfonylalkyl, alkylaminosulfonyl, alkylaminosulfonylalkyl, di(alkyl)aminosulfonyl, di(alkyl)aminosulfonylalkyl, carboxyl, trihalo substituted lower alkyl and trihalo substituted lower alkoxy.

Most preferably,  $R_1$  is selected from the group consisting of phenyl optionally substituted with 1 to 5 substituents independently selected from the group consisting of methoxy, chlorine and fluorine.

Preferred embodiments for compounds of the present invention include compounds of Formula 1 wherein A is selected from the group consisting of  $-N(R_4)(CH_2)_x-$ ,  $-O(CH_2)_x-$ ,  $-S(CH_2)_x-$ ,  $-SO_2(CH_2)_x-$ ,  $-SO_2N(CH_2)_x-$ ,  $-NSO_2(CH_2)_x-$ ,  $-N(R_4)(CH_2)_{1-4}O(CH_2)_x-$  and  $-N(R_4)(CH_2)_{1-4}NH(CH_2)_x-$ ; wherein x is an integer from 0 to 3.

More preferably, A is selected from the group consisting of  $-N(R_4)(CH_2)_x-$ ,  $-O(CH_2)_x-$ ,  $-S(CH_2)_x-$ ,  $-SO_2(CH_2)_x-$ ,  $-SO_2N(CH_2)_x-$ ,  $-NSO_2(CH_2)_x-$ ,  $-N(R_4)(CH_2)_{1-4}O(CH_2)_x-$  and  $-N(R_4)(CH_2)_{1-4}NH(CH_2)_x-$ ; wherein x is an integer from 0 to 1.

Most preferably, A is selected from the group consisting of  $-N(R_4)(CH_2)_x-$  and  $-O(CH_2)_x-$ ; wherein x is an integer from 0 to 1.

30

Preferred embodiments for compounds of the present invention include compounds of Formula 1 wherein  $R_4$  is selected from the group consisting of H, alkyl, lower alkyl, alkoxyalkyl, alkenyl, lower alkenyl, hydroxyalkyl, aryl, arylalkyl and heteroaryl.

More preferably,  $R_4$  is selected from the group consisting of H, lower alkyl and hydroxyalkyl.

5           Most preferably,  $R_4$  is H.

Embodiments for compounds of the present invention include compounds of Formula 1 wherein  $R_2$  is selected from the group consisting of heteroaryl and biheteroaryl optionally substituted with 1 to 2 substituents  
10   independently selected from  $R_7$  and optionally substituted with 1 substituent selected from  $R_8$ ; wherein  $R_7$  is substituted on the 2 or 6 position from the point of attachment of  $R_2$ ; and, wherein  $R_8$  is substituted on a carbon atom at the 4 or 5 position from the point of attachment of  $R_2$ .

15           Preferably,  $R_2$  is selected from the group consisting of heteroaryl optionally substituted with 1 substituent selected from  $R_7$  and substituted with 1 substituent selected from  $R_8$ ; wherein  $R_7$  is substituted on the 2 or 6 position from the point of attachment of  $R_2$ ; and, wherein  $R_8$  is substituted on a carbon atom at the 4 or 5 position from the point of attachment of  $R_2$ .

20

More preferably,  $R_2$  is selected from the group consisting of thienyl, pyrrolyl, oxazolyl, thiazolyl, imidazolyl, pyrazolyl, isoxazolyl, isothiazolyl, pyridinyl, pyridazinyl, pyrimidinyl and pyrazinyl optionally substituted with 1 substituent selected from  $R_7$  and substituted with 1 substituent selected from  $R_8$ ;  
25   wherein  $R_7$  is substituted on the 2 or 6 position from the point of attachment of  $R_2$ ; and, wherein  $R_8$  is substituted on a carbon atom at the 4 or 5 position from the point of attachment of  $R_2$ .

Most preferably,  $R_2$  is selected from the group consisting of pyridinyl,  
30   pyridazinyl, pyrimidinyl and pyrazinyl optionally substituted with 1 substituent selected from  $R_7$  and substituted with 1 substituent selected from  $R_8$ ; wherein  $R_7$  is substituted on the 2 or 6 position from the point of attachment of  $R_2$ ; and, wherein  $R_8$  is substituted on a carbon atom at the 4 or 5 position from the point of attachment of  $R_2$ .

Preferred embodiments for compounds of the present invention include compounds of Formula 1 wherein  $R_7$  is selected from the group consisting of lower alkyl, lower alkoxy, heterocyclalkyl, aryl, arylalkyl, OH, hydroxyalkyl, halogen, cyano, nitro, amino, alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, acyl, carboxyl, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy.

More preferably,  $R_7$  is selected from the group consisting of lower alkyl, OH, halogen, cyano, nitro, amino, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy.

Most preferably,  $R_7$  is selected from the group consisting of methyl, ethyl, OH, bromine, chlorine, fluorine, cyano, nitro, amino, trifluoromethyl and trifluoromethoxy.

Preferred embodiments for compounds of the present invention include compounds of Formula 1 wherein  $R_8$  is selected from the group consisting of OH, amino, (hydroxyalkyl)amino, alkoxycarbonyl,  $\text{OCON}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_n\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{CH}(\text{R}_5)_2$ ,  $\text{NH}(\text{CH}_2)_n\text{SO}_2(\text{CH}_2)_m\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{OCH}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{O}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_n\text{SO}_2\text{NH}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{CH}(\text{OH})(\text{CH}_2)_m\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{CH}(\text{OH})(\text{CH}_2)_m\text{OR}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{CH}(\text{OH})(\text{CH}_2)_m\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_n\text{CO}(\text{CH}_2)_m\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_n\text{CO}_2(\text{CH}_2)_m\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{CO}(\text{CH}_2)_m\text{SO}_2\text{NH}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{O}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{CO}(\text{CH}_2)_m\text{R}_5$ ,  $\text{CONH}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$  and  $\text{CONH}(\text{CH}_2)_n\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ; wherein  $n$  is an integer from 0 to 6 and  $m$  is an integer from 0 to 4; with the proviso, that  $m$  is at least 1 when  $R_5$  is selected from the group consisting of OH, amino, alkylamino and di(alkyl)amino.

More preferably,  $R_8$  is selected from the group consisting of OH, amino, (hydroxyalkyl)amino, alkoxycarbonyl,  $\text{OCON}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_n\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{CH}(\text{R}_5)_2$ ,  $\text{NH}(\text{CH}_2)_n\text{SO}_2(\text{CH}_2)_m\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$ ,

$\text{NH}(\text{CH}_2)_n\text{OCH}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{O}(\text{CH}_2)_m\text{R}_5$ ,  
 $\text{NH}(\text{CH}_2)_n\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_n\text{SO}_2\text{NH}(\text{CH}_2)_m\text{R}_5$ ,  
 $\text{NH}(\text{CH}_2)_n\text{CH}(\text{OH})(\text{CH}_2)_m\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{CH}(\text{OH})(\text{CH}_2)_m\text{OR}_5$ ,  
 $\text{NH}(\text{CH}_2)_n\text{CH}(\text{OH})(\text{CH}_2)_m\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_n\text{CO}(\text{CH}_2)_m\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ,  
5  $\text{NH}(\text{CH}_2)_n\text{CO}_2(\text{CH}_2)_m\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{CO}(\text{CH}_2)_m\text{SO}_2\text{NH}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{R}_5$ ,  
 $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{O}(\text{CH}_2)_m\text{R}_5$ ,  
 $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{CO}(\text{CH}_2)_m\text{R}_5$ ,  $\text{CONH}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$  and  
 $\text{CONH}(\text{CH}_2)_n\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ; wherein  $n$  is an integer from 0 to 5 and  $m$  is an  
integer from 0 to 2; with the proviso, that  $m$  is at least 1 when  $\text{R}_5$  is selected from  
10 the group consisting of OH, amino, alkylamino and di(alkyl)amino.

Most preferably,  $\text{R}_8$  is selected from the group consisting of OH, amino,  
(2-hydroxyethyl)amino, (3-hydroxy-*n*-propyl)amino, (4-hydroxy-*n*-butyl)amino,  
ethoxycarbonyl,  $\text{OCON}(\text{R}_5)_2$ ,  $\text{NH}(\text{CH}_2)_{1-4}\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_{1-3}\text{SO}_2(\text{CH}_2)_{0-1}\text{R}_5$ ,  
15  $\text{NH}(\text{CH}_2)_{1-3}\text{O}(\text{CH}_2)_{0-1}\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_{1-4}\text{OCH}[(\text{CH}_2)_{1-2}\text{R}_5]_2$ ,  
 $\text{NH}(\text{CH}_2)_{1-3}\text{O}(\text{CH}_2)_{1-2}\text{O}(\text{CH}_2)_{1-2}\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_{1-4}\text{N}[(\text{CH}_2)_{0-2}\text{R}_5]_2$ ,  
 $\text{NH}(\text{CH}_2)_{1-4}\text{SO}_2\text{NH}(\text{CH}_2)_{1-2}\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_{1-4}\text{CH}(\text{OH})(\text{CH}_2)_{1-2}\text{R}_5$ ,  
 $\text{NH}(\text{CH}_2)_{1-4}\text{CH}(\text{OH})(\text{CH}_2)_{1-2}\text{OR}_5$ ,  $\text{NH}(\text{CH}_2)_{1-4}\text{CH}(\text{OH})(\text{CH}_2)_{1-2}\text{N}[(\text{CH}_2)_{0-1}\text{R}_5]_2$ ,  
 $\text{NH}(\text{CH}_2)_{1-3}\text{CO}(\text{CH}_2)_{0-1}\text{N}[(\text{CH}_2)_{0-1}\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_{1-3}\text{CO}_2(\text{CH}_2)_{0-1}\text{R}_5$ ,  
20  $\text{NH}(\text{CH}_2)_{1-4}\text{CO}(\text{CH}_2)_{1-2}\text{SO}_2\text{NH}(\text{CH}_2)_{1-2}\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_{0-1}\text{R}_5$ ,  
 $\text{NHCO}(\text{CH}_2)_{1-3}\text{O}(\text{CH}_2)_{0-2}\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_{1-2}\text{O}(\text{CH}_2)_{1-2}\text{O}(\text{CH}_2)_{1-2}\text{R}_5$ ,  
 $\text{NHCO}(\text{CH}_2)_{1-2}\text{O}(\text{CH}_2)_{0-1}\text{CO}(\text{CH}_2)_{1-2}\text{R}_5$ ,  $\text{CONH}(\text{CH}_2)_{1-3}\text{O}(\text{CH}_2)_{0-2}\text{R}_5$  and  
 $\text{CONH}(\text{CH}_2)_{1-3}\text{N}[(\text{CH}_2)_{1-2}\text{R}_5]_2$ ; with the proviso, that the  $\text{R}_5$  alkylene linking  
group is at least methylene when  $\text{R}_5$  is selected from the group consisting of OH,  
25 amino, alkylamino and di(alkyl)amino.

Preferred embodiments for compounds of the present invention include  
compounds of Formula 1 wherein  $\text{R}_5$  is selected from the group consisting of H,  
OH, lower alkyl, amino, alkylamino, di(alkyl)amino, aryl, heteroaryl and  
30 heterocyclyl; wherein aryl, heteroaryl and heterocyclyl are optionally substituted  
with 1 to 3 substituents independently selected from the group consisting of  
lower alkyl, acyl, carboxyl, aryl (optionally substituted with one halogen  
substituent), di(alkyl)amino; alkylsulfonyl, aminosulfonyl, alkylaminosulfonyl  
and aminosulfonylalkyl; and, wherein heterocyclyl is further optionally

substituted with 1 to 3 oxo substituents.

More preferably, R<sub>5</sub> is selected from the group consisting of H, OH, lower alkyl, heteroaryl and heterocyclyl; wherein heterocyclyl is optionally substituted with 1 to 3 substituents independently selected from the group consisting of lower alkyl, acyl, carboxyl, aryl (optionally substituted with one halogen substituent), di(alkyl)amino, alkylsulfonyl, aminosulfonyl, alkylaminosulfonyl, aminosulfonylalkyl and oxo.

Most preferably, R<sub>5</sub> is selected from the group consisting of H, OH, methyl, ethyl, *t*-butyl, 1*H*-azetidiny, 1*H*-pyrrolidinyl, 4-tetrahydro-2*H*-pyranyl, hexahydro-1*H*-azepinyl, 1,3-dioxolanyl, 1,3-dioxanyl, piperidinyl, piperazinyl, imidazolyl, pyrazolyl, triazolyl and pyridinyl; wherein 1,3-dioxolanyl, 1,3-dioxanyl, piperazinyl and piperidinyl are optionally substituted with 1 to 2 substituents independently selected from the group consisting of methyl, acetyl, carboxyl, phenyl (optionally substituted with chlorine), di(methyl)amino, methylsulfonyl, methylaminosulfonyl and oxo.

Preferred embodiments for compounds of the present invention include compounds of Formula 1 wherein R<sub>3</sub> is selected from the group consisting of H, lower alkyl, lower alkoxy, OH, halogen, cyano, amino, alkylamino and di(alkyl)amino.

More preferably, R<sub>3</sub> is selected from the group consisting of H, lower alkyl, lower alkoxy, OH, halogen, amino and di(alkyl)amino.

Most preferably, R<sub>3</sub> is selected from the group consisting of H and methyl.

Preferred embodiments for compounds of the present invention include those compounds of Formula 1 selected from the group consisting of:

Cmd

4 3-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-propanol  
5 6-(5-amino-3-pyridinyl)-*N*-(3-chlorophenyl)-2-pyrazinamine

- 10 3-[[5-[2-[(3-chlorophenyl)amino]-6-methyl-4-pyrimidinyl]-3-pyridinyl]amino]-1-propanol
- 31 2-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]-ethanol
- 32 4-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-butanol
- 33 *N*<sup>1</sup>-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-*N*<sup>2</sup>,*N*<sup>2</sup>-dimethyl-1,2-ethanediamine
- 34 *N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-4-morpholinepropanamine
- 35 *N*<sup>1</sup>-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-*N*<sup>3</sup>,*N*<sup>3</sup>-dimethyl-1,3-propanediamine
- 41 *N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-2-methoxyacetamide
- 43 *N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-3-pyridinecarboxamide
- 52 3-[[5-[6-[(3-fluorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-propanol
- 57 3-[[5-[6-[(3-methoxyphenyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-propanol
- 62 3-[[5-[6-[(phenylmethyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-propanol
- 69 *N*-(3-chlorophenyl)-6-[5-[[3-(1-piperazinyl)propyl]amino]-3-pyridinyl]-2-pyrazinamine
- 70 *N*-(3-chlorophenyl)-6-[5-[[4-(4-pyridinyl)butyl]amino]-3-pyridinyl]-2-pyrazinamine
- 71 *N*-(3-chlorophenyl)-6-[5-[[3-(4-pyridinyl)propyl]amino]-3-pyridinyl]-2-pyrazinamine
- 72 *N*-(3-chlorophenyl)-6-[5-[[3-(3-pyridinyl)propyl]amino]-3-pyridinyl]-2-pyrazinamine
- 74 *N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-1-pyrrolidinecarboxamide
- 75 *N*-(3-chlorophenyl)-6-[5-[[3-(1*H*-pyrazol-1-yl)propyl]amino]-3-pyridinyl]-2-pyrazinamine
- 76 *N*-(3-chlorophenyl)-6-[5-[[3-(1*H*-1,2,4-triazol-1-yl)propyl]amino]-3-pyridinyl]-2-pyrazinamine
- 77 *N*-(3-chlorophenyl)-6-[5-[[3-(1*H*-imidazol-1-yl)propyl]amino]-3-pyridinyl]-2-pyrazinamine
- 78 2-[2-[2-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]ethoxy]ethoxy]-ethanol
- 79 *N*-(3-chlorophenyl)-6-[5-[[3-(tetrahydro-2*H*-pyran-4-yl)methyl]amino]-3-pyridinyl]-2-pyrazinamine
- 84 4-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]-butanoic acid ethyl ester
- 85 *N*-(3-chlorophenyl)-6-[5-[[2-(2-methoxyethoxy)ethyl]amino]-3-pyridinyl]-2-pyrazinamine
- 88 *N*-(4-methoxyphenyl)-6-[5-[[3-(4-pyridinyl)propyl]amino]-3-pyridinyl]-2-pyrazinamine
- 89 *N*-(3,4-dichlorophenyl)-6-[5-[[3-(4-pyridinyl)propyl]amino]-3-pyridinyl]-2-pyrazinamine

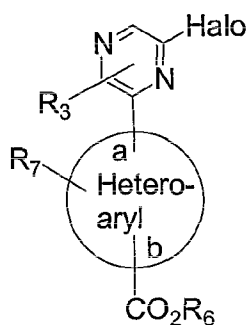


- 90 3-[[6'-[(3-chlorophenyl)amino][2,2'-bipyrazin]-6-yl]amino]-1-propanol  
 93 3-[[4-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-propanol  
 95 3-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-2-thiazolyl]amino]-1-propanol  
 98 *N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-2-(2-methoxyethoxy)-acetamide  
 102 *N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-2-ethoxy-acetamide  
 103 *N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-3-methoxy-propanamide  
 and  
 105 *N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-2-hydroxy-acetamide

### Intermediates

The present invention also is directed towards compounds used to synthesize the compounds of Formula I. Thus, the present invention provides

- 5 intermediate compounds of Formula 3:



Formula 3

wherein

Halo is selected from the group consisting of chloro, fluoro, bromo and iodo;

10

Heteroaryl is selected from the group consisting of thienyl, furyl, pyrrole, oxazolyl, thiazolyl, imidazolyl, pyrazolyl, isoxazolyl, isothiazolyl, oxadiazolyl, triazolyl, thiadiazolyl, 2*H*-pyranyl, pyridinyl, pyrazinyl, pyridazinyl, pyrimidinyl, indoliziny, isoindoyl and 3*H*-indolyl;

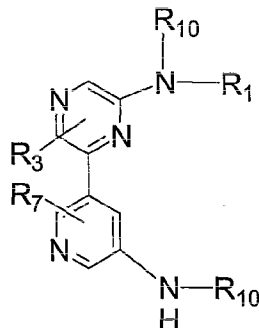
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“a” is the position of attachment for Heteroaryl to the pyrazine ring and “b” is the position of attachment for CO<sub>2</sub>R<sub>6</sub> to the Heteroaryl ring wherein “a” and “b” are carbon atoms;

- 20 R<sub>6</sub> is lower alkyl; and,

all other variables are as defined previously.

In particular, the present invention provides an intermediate useful in the synthesis of substituted 3-pyridinyl-pyrazine derivatives of the formula:



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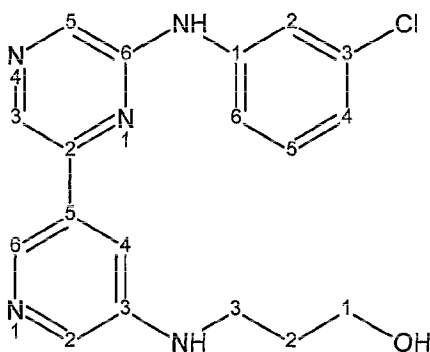
wherein

R<sub>10</sub> is a protecting group selected from the group consisting of t-butoxycarbonyl, benzyloxycarbonyl, and *N*-(9-fluorenylmethoxycarbonyl); and,

10 all other variables are as defined previously.

### Nomenclature

Compounds are named according to nomenclature well known in the art, exemplified using ring numbering as follows:



15

3-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-propanol  
Names can be generated using a nomenclature system based on this example, or may be generated using commercial chemical naming software, preferably ACD/Index Name (Advanced Chemistry Development, Inc., Toronto, Ontario).

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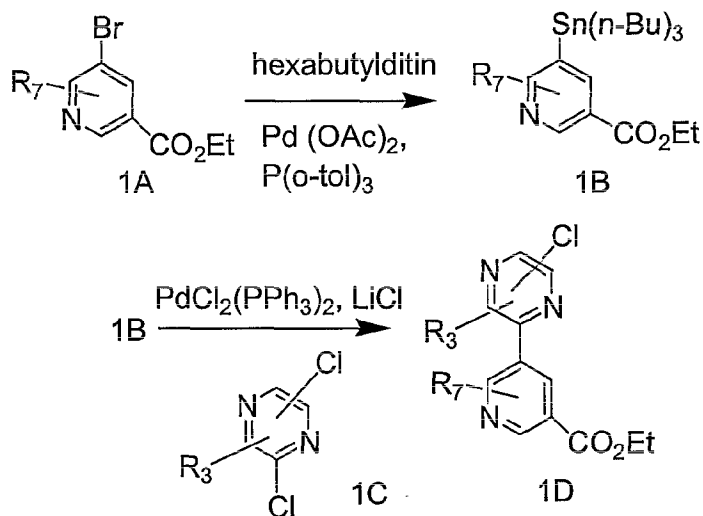
### General Synthetic Schemes

The invention can be better understood by way of the following schemes.

These schemes are representative of the preferred synthetic methods, but are not to be construed as limiting the scope of the invention.

### Scheme 1

- 5 A mixture of 5-bromonicotinate Compound **1A** (substituted or unsubstituted with  $R_7$ ), bis(tributyltin), palladium acetate, tri-*o*-tolylphosphine and triethylamine in a suitable solvent, such as acetonitrile, is stirred under nitrogen. The cooled reaction mixture is filtered, washed, and the mixture is concentrated under vacuum. The residue is diluted with a suitable solvent, such as dichloromethane, washed with a suitable aqueous solvent, and concentrated.
- 10 The residue is further diluted with a suitable solvent, such as hexane, filtered, and the filtrate is concentrated. The product is purified by column chromatography to give Compound **1B**. A mixture of Compound **1B**, 2, 6-dichloropyrazine (Compound **1C**), dichloro-bis(triphenylphosphine)palladium and LiCl in anhydrous toluene is stirred under nitrogen. The cooled reaction mixture is concentrated under vacuum. Aqueous solvent is added to the residue and stirred and then extracted with a suitable solvent, such as dichloromethane. The combined solution is filtered, dried, and concentrated. The product is purified by column chromatography to give Compound **1D** as an off-white solid.



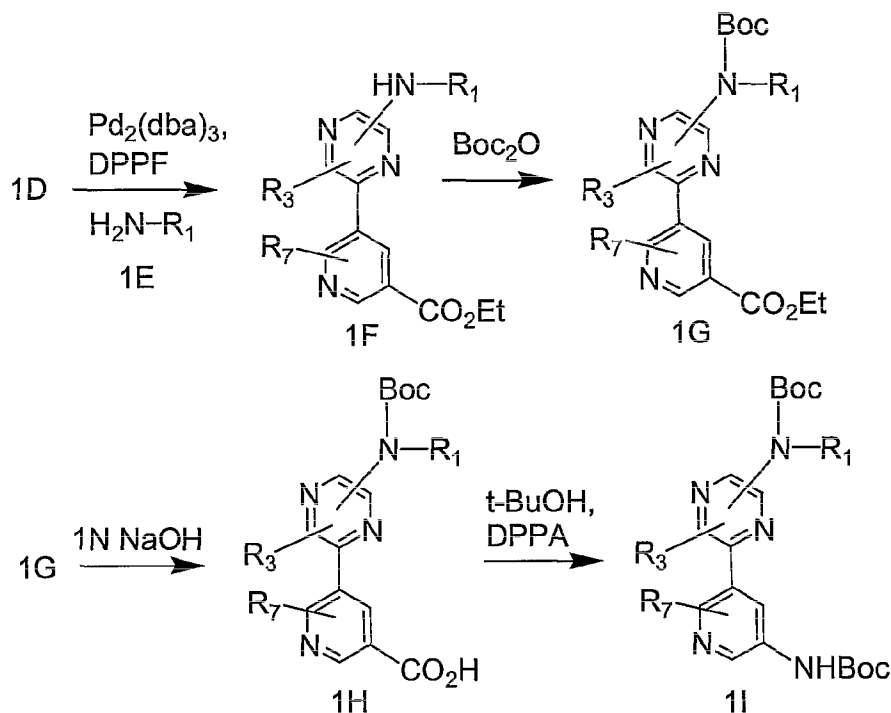
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- A mixture of Compound **1D**, Compound **1E**,  $\text{Pd}_2(\text{dba})_3$ , DPPF, and  $\text{Cs}_2\text{CO}_3$  in anhydrous dioxane is stirred under nitrogen. The reaction is cooled and a suitable solvent, such as dichloromethane, is added. The diluted reaction is filtered, washed with more solvent, and the combined filtrate is concentrated to
- 25

give Compound **1F**. The Compound **1F** is diluted with a small amount of a suitable solvent, such as dichloromethane. The solid is collected through filtration, and the filtrate is concentrated. The Compound **1F** may be recrystallized from EtOAc/hexane.

5

A mixture of Compound **1F**,  $\text{Boc}_2\text{O}$ , and DMAP in a suitable solvent, such as dichloromethane is stirred. The reaction mixture is concentrated and the product is purified by column chromatography (EtOAc/hexane as solvent) to give Compound **1G**.



10

Compound **1G** is dissolved in a suitable solvent, such as methanol, and stirred, and then cooled to about  $0^\circ\text{C}$ . A  $\text{NaOH}_{(\text{aq})}$  (1 N) solution is added slowly and the mixture is stirred at about  $0^\circ\text{C}$ , followed by stirring at about  $20^\circ\text{C}$ . Glacial acetic acid is slowly added to the reaction mixture at about  $0^\circ\text{C}$  followed by the addition of water. A solid is formed, and is collected through filtration, washed with water, and then dried in a vacuum oven to give the carboxylic acid Compound **1H**.

15

A mixture of the carboxylic acid Compound **1H**, DPPA, triethylamine, and  $t\text{-BuOH}$  in toluene is stirred under nitrogen at about  $70^\circ\text{C}$ , and then stirred at about  $100^\circ\text{C}$ . The reaction mixture is concentrated under vacuum. The

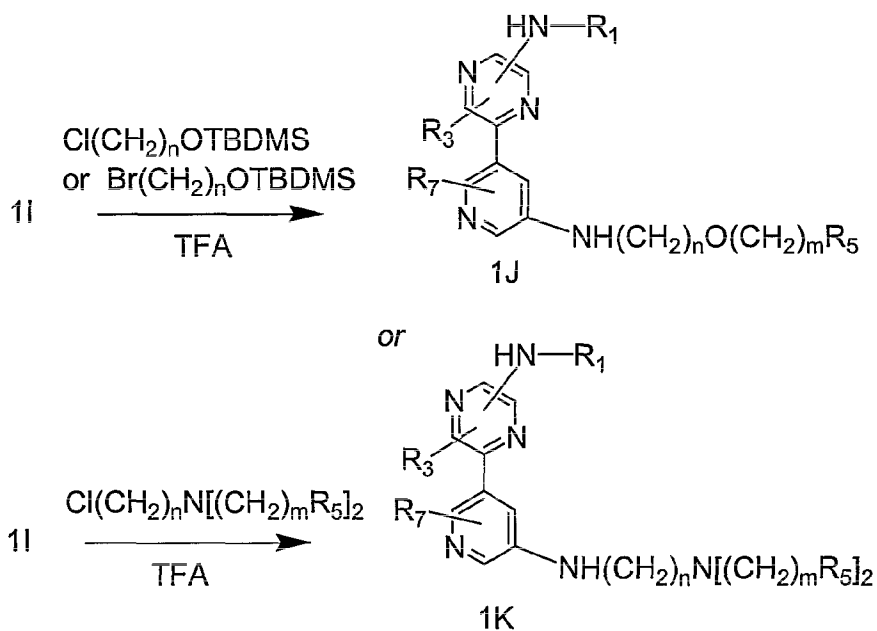
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product is purified by column chromatography to give Compound **1I**.

**Scheme 1 Alternate Substituent Pattern #1**

A mixture of Compound **1I**, (haloalkoxy)-t-butyl-dimethylsilane, and  
 5  $\text{Cs}_2\text{CO}_3$  in DMF is stirred at about 70 °C under nitrogen. The reaction mixture is  
 diluted with water, extracted, dried, and concentrated. The product is purified by  
 column chromatography to give a silylated-product. The silylated-product is  
 dissolved in a suitable solvent, such as TFA, stirred, and then concentrated. An  
 ammonium hydroxide solution is added to the residue until the pH is about 10-  
 10 11, water is added, and a solid is formed. The solid is collected through  
 filtration, washed with water, and dried under vacuum to give Compound **1J**.  
 Alternatively, the same procedure can be performed with a substituted  
 aminoalkylhalo replacing the (haloalkoxy)-t-butyl-dimethylsilane to yield  
 Compound **1K**.

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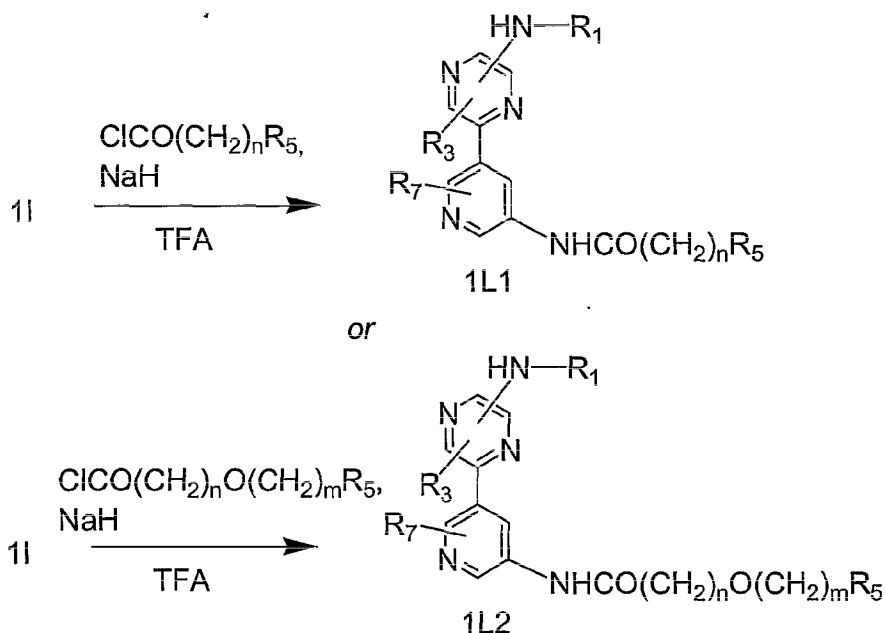


**Scheme 1 Alternate Substituent Pattern #2**

Compound **1I** is dissolved in anhydrous THF at about 0 °C and NaH is  
 20 added (60% oil dispersion).  $\text{R}_5(\text{CH}_2)_n\text{COCl}$  is added and the reaction is stirred at  
 about 0 °C under  $\text{N}_2$ , and then allowed to warm up.  $\text{NH}_4\text{Cl}_{(\text{aq})}$  is added to quench  
 the reaction. Solvent is removed and the product is extracted into  $\text{CH}_2\text{Cl}_2$ ,  
 washed with water, and dried. Product is purified by column chromatography to

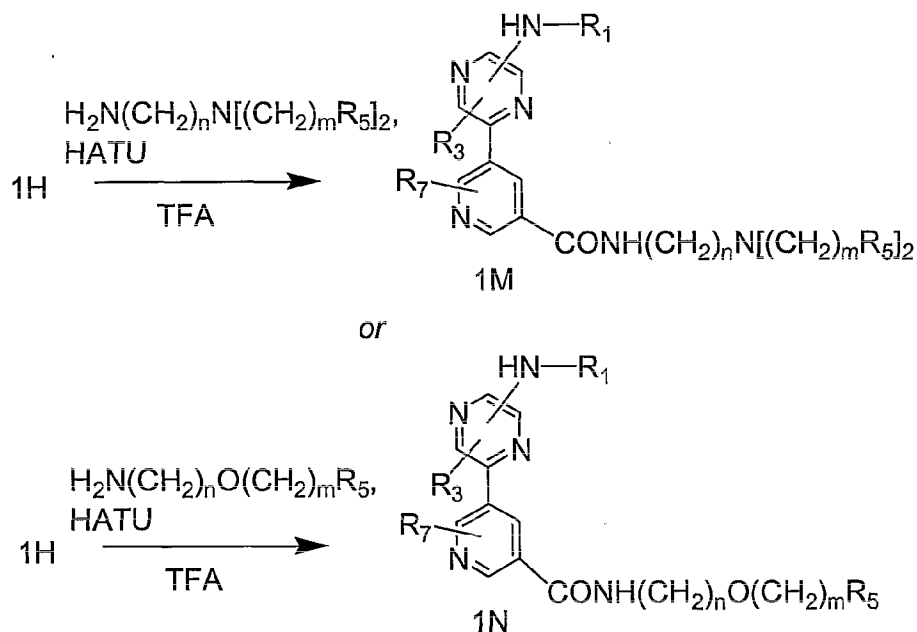
give a solid. The product is dissolved in a solvent, such as TFA, stirred, and concentrated. An ammonium hydroxide solution is added to the residue until the pH is about 10-11 and a solid is formed. The solid is collected through filtration, washed with water and dried under vacuum to give Compound **1L1**.

- 5 Alternatively, the same procedure can be performed with  $R_5(CH_2)_mO(CH_2)_nCOCl$  replacing  $R_5(CH_2)_nCOCl$  to yield Compound **1L2**.



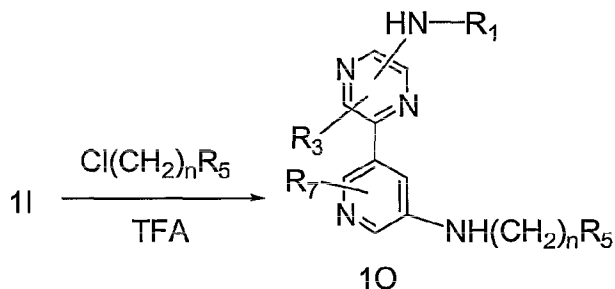
**Scheme 1 Alternate Substituent Pattern #3**

- 10 A mixture of Compound **1H**, alkoxyamine ( $NH_2(CH_2)_nO(CH_2)_mR_5$ ), diisopropylethylamine and HATU in DMF is stirred under  $N_2$ . Solvent is removed and the product is purified by column chromatography to generate a solid product. The solid is dissolved in a suitable solvent, stirred, and concentrated. An ammonium hydroxide solution is added to the residue until the
- 15 pH is about 10-11. The solid is collected through filtration, washed with water and dried under vacuum to give the final, purified product of Compound **1N**. Alternatively, using a substituted aminoalkylamine ( $NH_2(CH_2)_nN[(CH_2)_mR_5]_2$ ) in this scheme yields Compound **1M**.



#### Scheme 1 Alternate Substituent Pattern #4

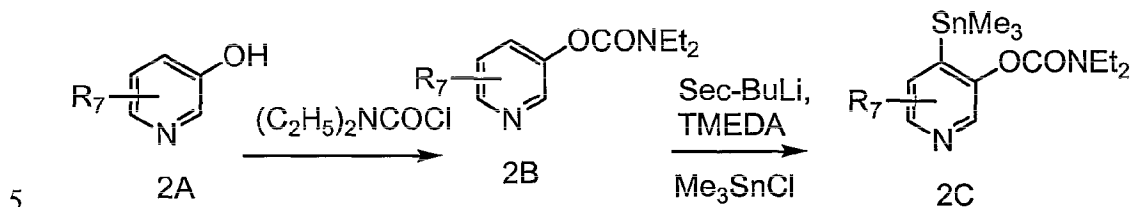
A mixture of Compound **1I**, substituted alkylchloride ( $\text{Cl}(\text{CH}_2)_n\text{R}_5$ ) and  $\text{Cs}_2\text{CO}_3$  in DMF is stirred under  $\text{N}_2$ . The reaction mixture is diluted with water, extracted with ether, dried with  $\text{Na}_2\text{SO}_4$  and concentrated. The product is purified by column chromatography, dissolved in TFA, stirred, concentrated and ammonium hydroxide solution is added to the residue until the pH is about 10-11. The aqueous layer is extracted, dried, concentrated and purified by column chromatography to give the final, purified product Compound **1O**.



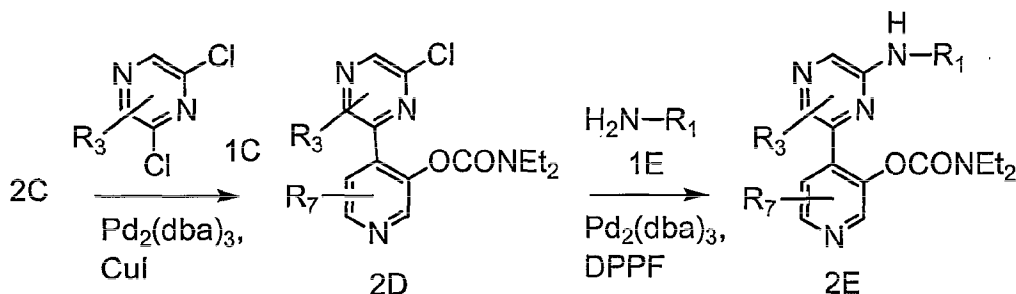
#### Scheme 2

3-Pyridyl diethyl carbamate (Compound **2B**) (1.0 g, 5.1 mmol) is prepared using commercially available Compound **2A** and standard methods (Wuest, H.M., Sakal, E.H. *J Am Chem Soc* 73 1210 1951) and is dissolved in a suitable solvent. This is cooled to about  $-78^\circ\text{C}$ , and then  $\text{sec-BuLi}$  and TMEDA are added under nitrogen. The reaction mixture is stirred at about  $-78^\circ\text{C}$ . Trimethyltin chloride in anhydrous solvent is added slowly and the reaction is

allowed to warm up.  $\text{NH}_4\text{Cl}_{(\text{aq})}$  is added to quench the reaction and the product is extracted, dried, and concentrated under vacuum. The product is purified by column chromatography to provide Compound **2C**.



A mixture of Compound **2C**, 2, 6-dichloropyrazine (Compound **1C**), tris-2-furyl phosphine, CuI, and  $\text{Pd}_2(\text{dba})_3$  in anhydrous NMP is stirred under nitrogen. The reaction is cooled and then concentrated under vacuum. The product is purified by column chromatography to give Compound **2D**.



15 A mixture of Compound **2D**, Compound **1E**,  $\text{Pd}_2(\text{dba})_3$ , DPPF and  $\text{Cs}_2\text{CO}_3$  in anhydrous dioxane is stirred under nitrogen. The reaction is cooled and a suitable solvent, such as dichloromethane, is added. The diluted reaction is filtered, washed with more solvent, and the combined filtrate is concentrated to give Compound **2E**. Compound **2E** is diluted with a small amount of a suitable solvent, such as dichloromethane. The solid is collected through filtration and the filtrate is concentrated. Compound **2E** is then dissolved in a suitable solvent, such as methanol, stirred and cooled to about 0 °C. A  $\text{NaOH}_{(\text{aq})}$  solution is added slowly and the mixture is stirred first at about 0 °C and then stirred at about 20 °C. Glacial acetic acid is slowly added to the reaction mixture at about 0 °C

20 followed by the addition of water. A solid is formed, and is collected through filtration, washed with water, and then dried in a vacuum oven to give

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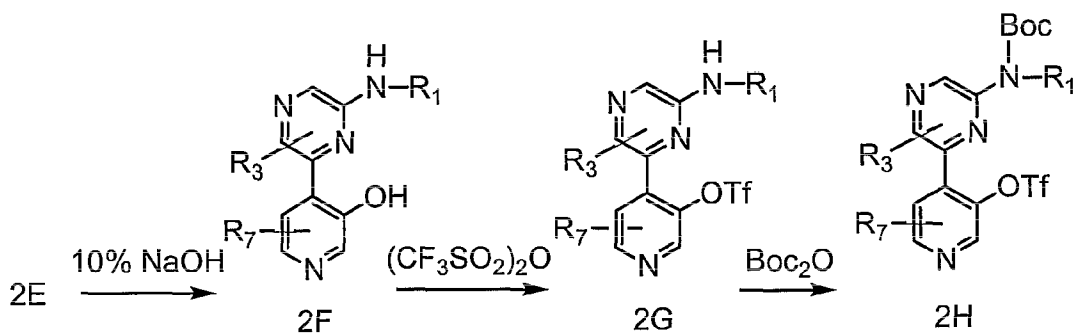


Compound **2F**.

Compound **2F** is dissolved in a cooled suitable solvent, such as in anhydrous  $\text{CH}_2\text{Cl}_2$  (5 mL) at  $0^\circ\text{C}$ , and  $(\text{CF}_3\text{SO}_2)_2\text{O}$  and triethylamine are added.

- 5 The reaction is stirred under nitrogen and then concentrated under vacuum. The product is purified by column chromatography to give the triflate Compound **2G**.

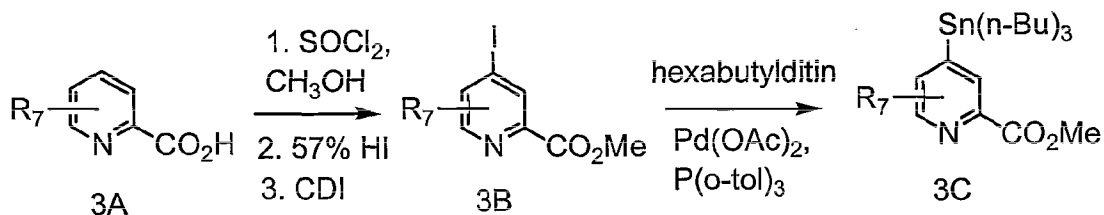
- 10 Compound **2G** is dissolved in solvent and treated with  $\text{Boc}_2\text{O}$  and DMAP by mixing the reaction under nitrogen. The solvent is removed under vacuum and the product is purified by column chromatography to give Compound **2H**.



### 15 **Scheme 3**

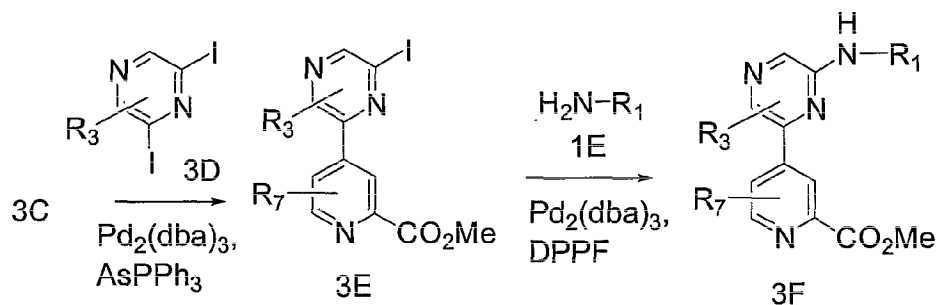
A mixture of Compound **3A**, 4-iodopicolinic acid (hemi-hydroiodide hydrate) and CDI in THF is stirred. The reaction mixture is cooled, and then a solvent, such as methanol, is added. Next triethylamine is added slowly. The reaction is stirred and then concentrated under vacuum. The product is purified

20 by column chromatography to give Compound **3B** as a solid. A mixture of Compound **3B**, bis(tributyltin), palladium acetate, tri-*o*-tolylphosphine and triethylamine in a suitable solvent such as acetonitrile is stirred under nitrogen. The cooled reaction mixture is concentrated under vacuum. The residue is purified by column chromatography to give Compound **3C**.



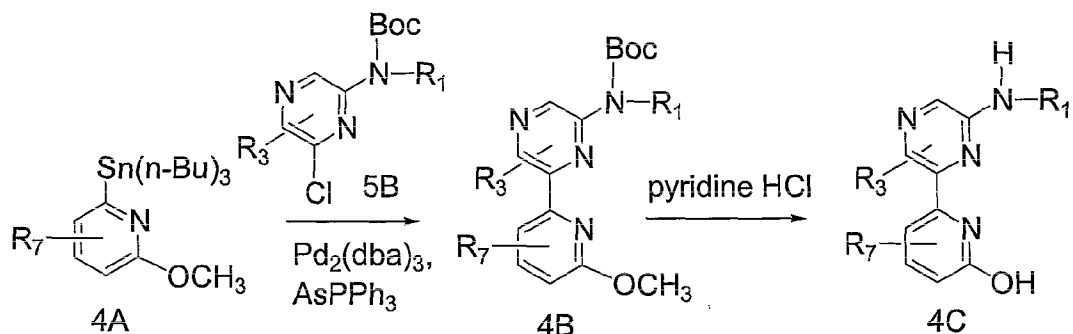
A mixture of Compound **3C**, 2,6-diiodopyrazine Compound **3D**,  $\text{Pd}_2(\text{dba})_3$ , and triphenylarsine in THF is stirred at reflux under nitrogen.

- 5 Aqueous solvent is added and stirred and then extracted with a suitable solvent, such as dichloromethane. The product is purified by column chromatography to give Compound **3E** as a solid. A mixture of Compound **3E**, Compound **1E**,  $\text{Pd}_2(\text{dba})_3$ , DPPF,  $\text{Cs}_2\text{CO}_3$  in anhydrous dioxane is stirred under nitrogen. The reaction mixture is concentrated under vacuum and purified by column
- 10 chromatography to give Compound **3F**.



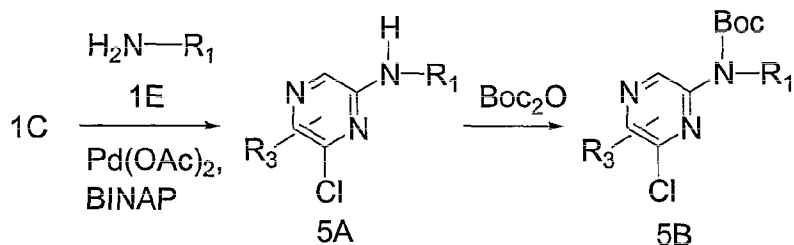
#### **Scheme 4**

- A mixture of 2-methoxy-6-(tributyltin)pyridine (Compound **4A**),
- 15 Compound **5B**,  $\text{Pd}_2(\text{dba})_3$ , triphenylarsine, and THF is refluxed under nitrogen. The product is purified by column chromatography and recrystallized from a solvent, such as hexane, to give a solid Compound **4B**. A mixture of Compound **4B** and pyridine hydrochloride is heated under nitrogen. The mixture is cooled, and then triturated in a mixture of a suitable solvent, such as dichloromethane,
- 20 and 30% ammonium hydroxide. Then the solvent is removed under vacuum. Solids are collected through filtration and dried under vacuum to give Compound **4C**.



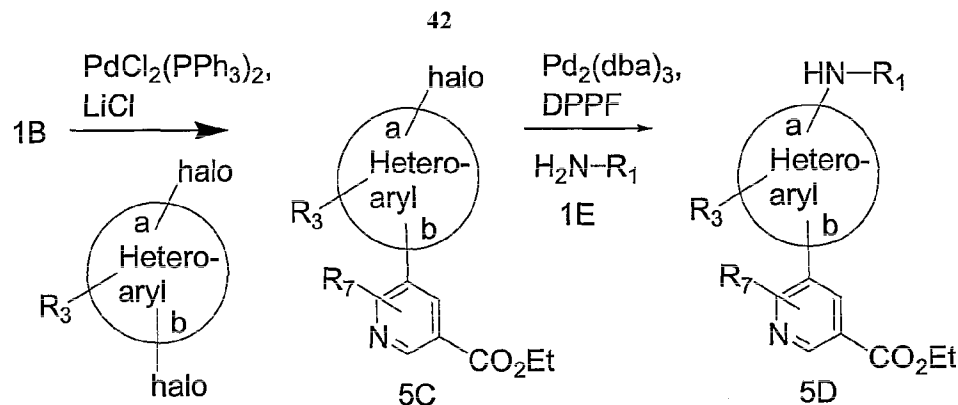
### **Scheme 5 Intermediate Product 5B**

Palladium acetate, BINAP, *t*-BuONa, 2,6-dichloropyrazine (Compound 1C), and Compound 1E in a solvent is stirred at about 80 °C for about 22 hours under Nitrogen.  $\text{CH}_2\text{Cl}_2$  is added, the reaction mixture is filtered through celite, and the solvent is evaporated. Product is purified by column chromatography to give Compound 5A. A mixture of Compound 5A,  $\text{Boc}_2\text{O}$ , and DMAP in a suitable solvent, such as dichloromethane, is stirred at about 20 °C for about 16 hours. The reaction mixture is concentrated and the product is purified by column chromatography to give Compound 5B.



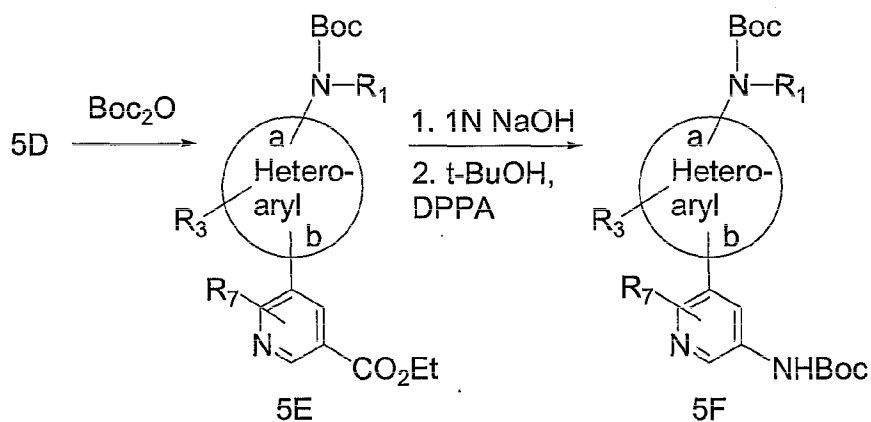
### **Scheme 5 Alternative Substitution Pattern #1 Using Palladium Chemistry**

A mixture of Compound 1B, a dihaloheteroaryl compound, dichloro-bis(triphenylphosphine)palladium and LiCl in anhydrous toluene is stirred under nitrogen. The reaction is cooled and then concentrated under vacuum. Aqueous solvent is added to the residue, stirred, and then extracted with a suitable solvent, such as dichloromethane. The solution is filtered, dried, and concentrated. The product is purified by column chromatography to give Compound 5C.



A mixture of Compound **5C**, Compound **1E**,  $\text{Pd}_2(\text{dba})_3$ , DPPF and  $\text{Cs}_2\text{CO}_3$  in anhydrous dioxane is stirred under nitrogen. The reaction is cooled and a suitable solvent, such as dichloromethane, is added. The diluted reaction is filtered and the filtrate is concentrated to give a product. The product is diluted with a small amount of a suitable solvent, such as dichloromethane. A solid is collected through filtration, the filtrate is concentrated and Compound **5D** may be recrystallized from EtOAc/hexane.

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A mixture of Compound **5D**,  $\text{Boc}_2\text{O}$ , and DMAP in a suitable solvent, such as dichloromethane is stirred. The reaction mixture is concentrated and the product is purified by column chromatography to give Compound **5E**.

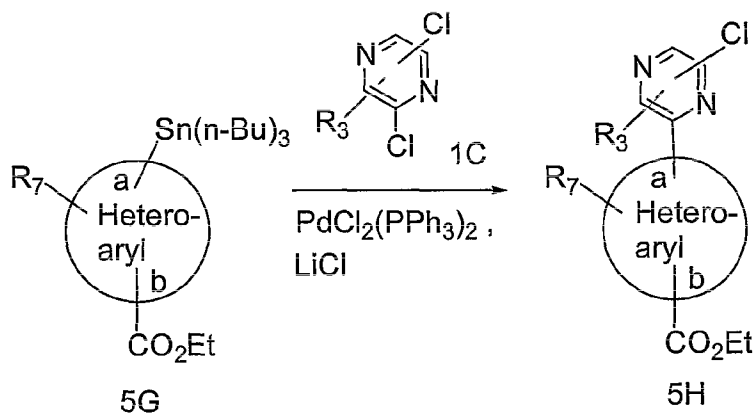
Compound **5E** is dissolved in a suitable solvent, such as methanol, stirred, and then cooled to  $0^\circ\text{C}$ . A  $\text{NaOH}_{(\text{aq})}$  (1 N) solution is added slowly and the mixture is stirred at about  $0^\circ\text{C}$  for 20 min. and then stirred for an additional 18 hours at about  $20^\circ\text{C}$ . Glacial acetic acid is added to the reaction mixture at about  $0^\circ\text{C}$

slowly followed by the addition of water. A solid is formed and is collected

through filtration, washed with water, and then dried in a vacuum oven to give a carboxylic acid derivative. The carboxylic acid derivative, DPPA, triethylamine, and t-BuOH in toluene is stirred under nitrogen, and then stirred at about 100 °C. The reaction mixture is concentrated under vacuum. The product is purified by column chromatography to give Compound **5F**. Other compounds of the invention may be obtained by substituting Compound **5F** for Compound **1I** in any of the reactions described for use of Compound **1I** in **Scheme 1**.

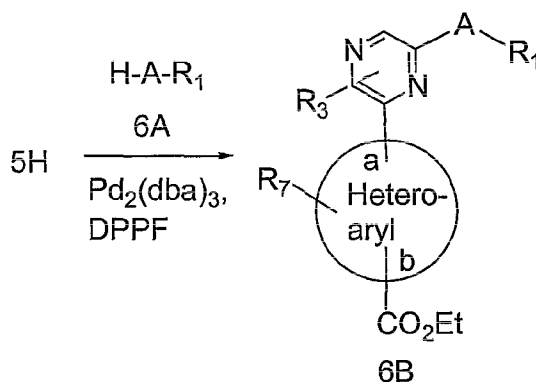
**Scheme 5 Alternative Substitution Pattern #2 Using Palladium Chemistry**

Using the methodology of **Scheme 1**, other compounds of the invention may have a heterocyclic substituent Compound **5G** attached to a pyrazine ring Compound **1C** to yield a target Compound **5H**. Compound **7B** is further used analogously to Compound **1D** in the methods of **Scheme 1**.



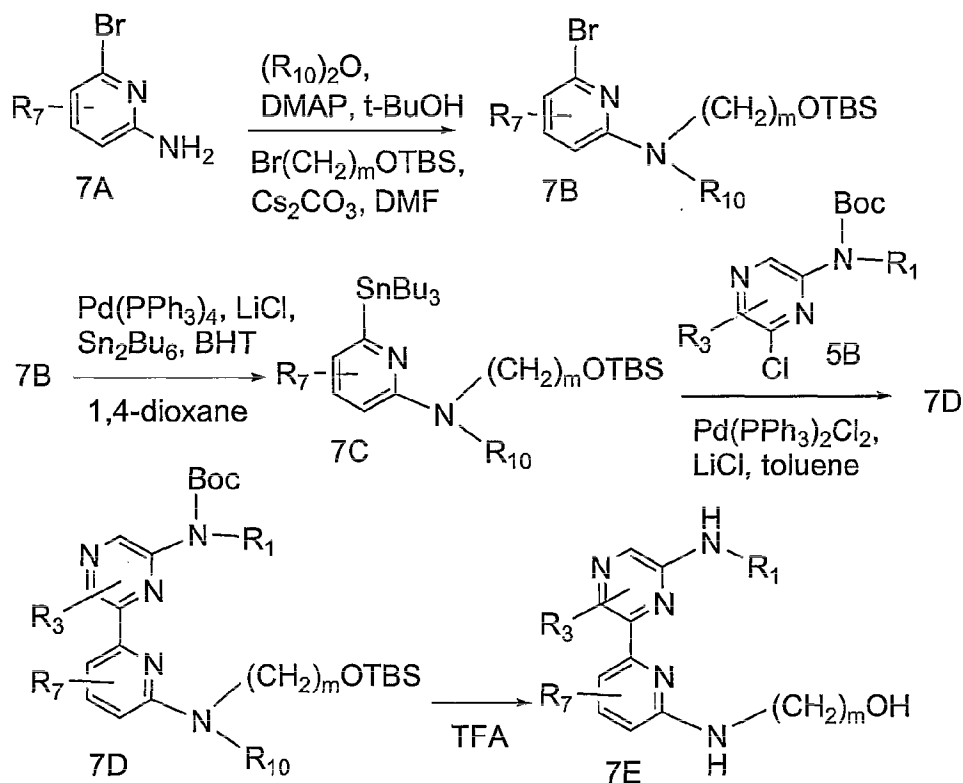
**Scheme 6**

To compounds of the invention wherein the "A" linking group is varied, a Compound **5H** is reacted with Compound **6A**,  $\text{Pd}_2(\text{dba})_3$ , DPPF and  $\text{Cs}_2\text{CO}_3$  in anhydrous dioxane by stirring the mixture under nitrogen. The reaction is cooled and a suitable solvent is added. The diluted reaction is filtered and the filtrate is concentrated to give Compound **6B**. Other compounds of the invention may be obtained by substituting Compound **6B** for Compound **1G** in any of the reactions described for use of Compound **1G** in **Scheme 1**.

**Scheme 7**

- Alternatively to Scheme 5 and 6, using palladium chemistry, target compounds of the invention may be obtained by mixing 2-amino-6-
- 5 bromopyridine Compound **7A** (optionally substituted with  $R_7$ ), an  $R_{10}$  protecting group such as di-*tert*-butyl dicarbonate and 4-(dimethylamino)pyridine in *t*-BuOH and stirring at room temperature for more than 24 h. Concentrating and purifying the solution by flash chromatography (using a solvent such as EtOAc/hexane) gives *N*-( $R_{10}$ )-2-amino-6-bromopyridine which is then mixed
- 10 with dry DMF and to the solution is added bromo-( $CH_2$ )<sub>*m*</sub>-*tert*-butyldimethylsilane and  $Cs_2CO_3$ . The mixture is stirred at 70 °C for 18 h, the solvent is evaporated under reduced pressure and the residue is purified by column chromatography to provide Compound **7B** as a clear oil.
- 15 A mixture of Compound **7B**, bis(tributyltin), tetrakis(triphenylphosphine)palladium, LiCl and 2,6-di-*tert*-butyl-4-methylphenol in anhydrous 1,4-dioxane is refluxed at 100 °C for 4 h under nitrogen. The solvent is removed under reduced pressure and the residue chromatographed over silica gel (using a solvent such as ethyl acetate/hexane) to
- 20 give Compound **7C** as a clear oil. A mixture of Compound **7C**, Compound **5B**, dichlorobis(triphenylphosphine)palladium and LiCl in anhydrous toluene is stirred at 100 °C for 3 h under nitrogen. The cooled reaction mixture is concentrated under vacuum and purified by flash chromatography to give Compound **7D** as a yellow oil. Compound **7D** is dissolved in TFA and the
- 25 solution stirred at room temperature for 2 h before concentration. A saturated  $NH_4OH$  solution is added to the residue until made basic and is followed by adding water to precipitate the solid. The precipitated solid is collected through

filtration, washed with water and Et<sub>2</sub>O, and dried under vacuum to provide the target Compound **7E** as a yellow solid.



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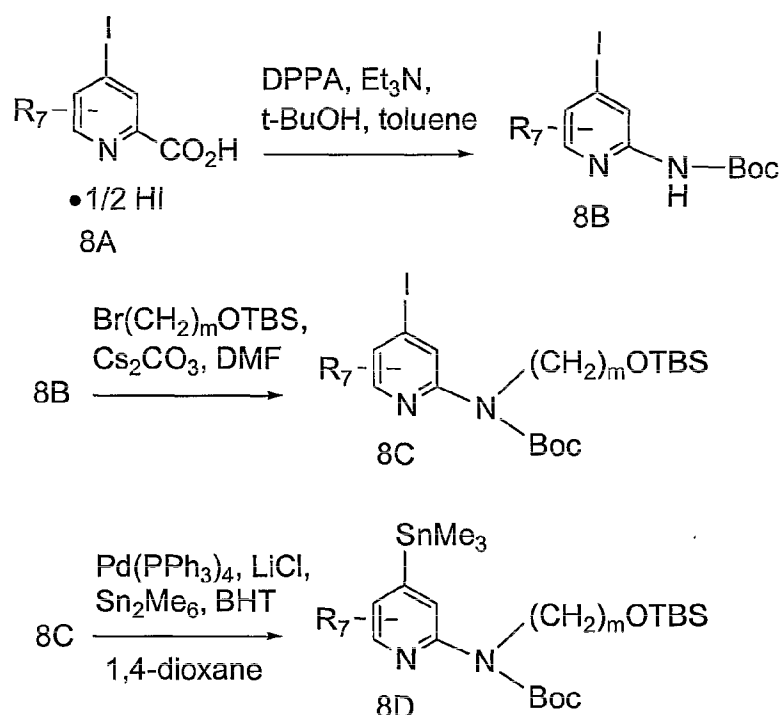
### Scheme 8

As an alternate substitution pattern for Scheme 7, target compounds of the invention may be obtained by mixing 4-iodopicolinic acid Compound **8A** (optionally substituted with R<sub>7</sub>) (prepared as described in Lohse, O. *Synth. Commun.* 1996, 26, 2017), DPPA and triethylamine in *t*-BuOH and toluene, heating the mixture at 65 °C for 1.5 h and then at 100 °C for 4 h. After concentrating the reaction mixture and purification by flash chromatography (using a solvent such as EtOAc/hexane), Compound **8B** is obtained as a white solid. A mixture of Compound **8B**, bromo-(CH<sub>2</sub>)<sub>m</sub>-*tert*-butyldimethylsilane and Cs<sub>2</sub>CO<sub>3</sub> in dry DMF is stirred at 70 °C for 3 h. The solvent is evaporated under reduced pressure and the residue purified by column chromatography (using a solvent such as EtOAc/hexane) to provide Compound **8C** as a clear oil. A mixture of Compound **8C**, bis(trimethyltin), tetrakis(triphenylphosphine)palladium, LiCl and BHT (2,6-di-*tert*-butyl-4-methylphenol) in anhydrous 1,4-dioxane is heated at 90 °C for 1.5 h under

20

nitrogen. The solvent is removed under reduced pressure and the residue chromatographed over silica gel (using a solvent such as EtOAc/hexane) to give Compound **8D** as a clear oil. Other compounds of the invention may be obtained by substituting Compound **8D** for Compound **7C** in the reaction described for

5 use of Compound **7C** in Scheme 7.



### Scheme 9

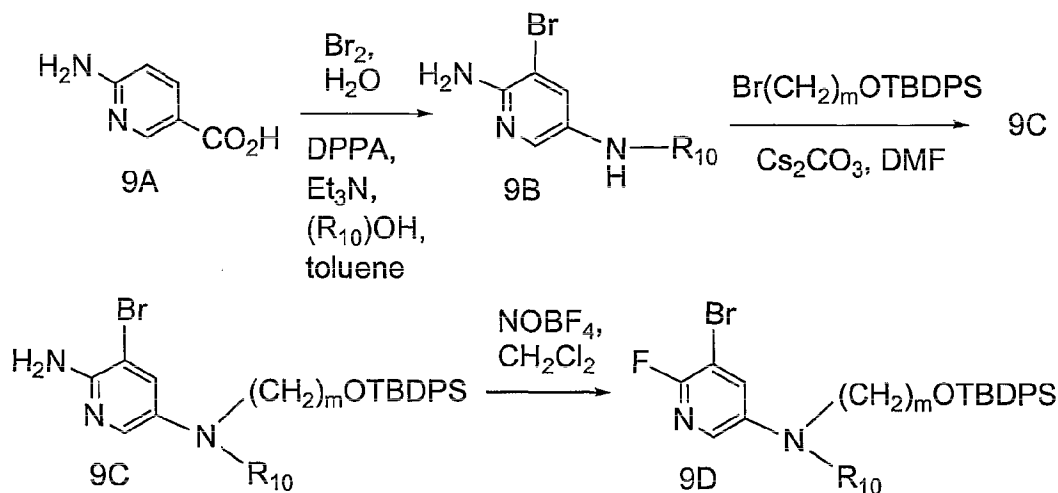
10 As an alternate substitution pattern for Scheme 7, target compounds of the invention wherein  $R_7$  is selected from halogen may be obtained by adding bromine dropwise to a suspension of 6-aminonicotinic acid Compound **9A** in water at 4 °C. After completion of the addition, the cooling bath is removed and the reaction mixture is stirred at room temperature for 4.5 h. Saturated  $Na_2S_2O_5$

15 is added slowly to the stirred mixture. The solid is then collected through filtration, washed with water, and dried under vacuum overnight to give a 6-amino-5-bromonicotinic acid intermediate along with a 3,5-dibromo-2-aminopyridine intermediate in approximately a 1:1 ratio as a greenish solid. A mixture of the solid containing the 6-amino-5-bromonicotinic acid intermediate,

20 DPPA, triethylamine, an  $R_{10}$  protecting group such as benzyl alcohol and toluene is heated at 70 °C for 1h, then 100 °C for 1h. After concentrating the reaction



mixture and purification by flash chromatography (using a solvent such as EtOAc/hexane), the Compound **9B** is obtained as a yellow solid. A mixture of Compound **9B**, bromo- $(\text{CH}_2)_m$ -*tert*-butyldiphenylsilane and  $\text{Cs}_2\text{CO}_3$  in dry DMF is heated at  $70^\circ\text{C}$  for 3h. The reaction mixture is concentrated and purified by column chromatography (using a solvent such as EtOAc/hexane) to give Compound **9C** as a yellow oil. To the solution of Compound **9C** in  $\text{CH}_2\text{Cl}_2$  at  $4^\circ\text{C}$  is added  $\text{NOBF}_4$  (nitrosonium tetrafluoroborate). After 1h at  $4^\circ\text{C}$ , more  $\text{NOBF}_4$  is added followed by the same amount of  $\text{NOBF}_4$  after another 1h. After stirring for a total of 3h at  $4^\circ\text{C}$ , water is added. The aqueous solution is extracted with a solvent such as  $\text{CH}_2\text{Cl}_2$ . The combined organic layers are dried, concentrated and flash chromatographed (using a solvent such as EtOAc/hexane) to give Compound **9D** as a yellow oil. Other compounds of the invention may be obtained by substituting Compound **9D** for Compound **7C** in the reaction described for use of Compound **7C** in Scheme 7.



### ProDrugs

The present invention includes within its scope prodrugs of the compounds of this invention. In general, such prodrugs will be functional derivatives of the compounds which are readily convertible *in vivo* into the required compound. Thus, in the methods of treatment of the present invention, the term "administering" shall encompass the treatment of the various disorders described with the compound specifically disclosed or with a compound which

may not be specifically disclosed, but which converts to the specified compound *in vivo* after administration to the subject. Conventional procedures for the selection and preparation of suitable prodrug derivatives are described, for example, in "Design of Prodrugs", ed. H. Bundgaard, Elsevier, 1985.

5

#### Pharmaceutical formulations

The instant pharmaceutical composition can be prepared according to conventional pharmaceutical techniques. A pharmaceutically acceptable carrier may be used in the composition of the invention. The composition may take a  
10 wide variety of forms depending on the form of preparation desired for administration including, but not limited to, intravenous (both bolus and infusion), oral, nasal, transdermally, topical with or without occlusion, intraperitoneal, subcutaneous, intramuscular, or parenteral, all using forms well known to those of ordinary skill in the pharmaceutical arts. In preparing the  
15 compositions in oral dosage form, one or more of the usual pharmaceutical carriers may be employed, such as water, glycols, oils, alcohols, flavoring agents, preservatives, coloring agents, syrup and the like in the case of oral liquid preparations (for example, suspensions, elixirs and solutions), or carriers such as starches, sugars, diluents, granulating agents, lubricants, binders, disintegrating  
20 agents and the like in the case of oral solid preparations (for example, powders, capsules and tablets).

The compounds may alternatively be administered parenterally via injection of a formulation consisting of the active ingredient dissolved in an inert  
25 liquid carrier. The injectable formulation can include the active ingredient mixed with an appropriate inert liquid carrier. Acceptable liquid carriers include vegetable oils such as peanut oil, cotton seed oil, sesame oil, and the like, as well as organic solvents such as solketal, glycerol formal, and the like. As an alternative, aqueous parenteral formulations may also be used. For example,  
30 acceptable aqueous solvents include water, Ringer's solution and an isotonic aqueous saline solution. Further, a sterile non-volatile oil can usually be employed as solvent or suspending agent in the aqueous formulation. The formulations are prepared by dissolving or suspending the active ingredient in the liquid carrier such that the final formulation contains from 0.005 to 10% by

weight of the active ingredient. Other additives including a preservative, an isotonizer, a solubilizer, a stabilizer and a pain-soothing agent may adequately be employed.

5           The compounds may alternatively be administered occularly via application of a formulation consisting of the active ingredient dissolved in an inert aqueous liquid carrier. Such aqueous liquid formulations are useful, for example in the treatment of diabetic retinopathy. Acceptable aqueous solvents include water, Ringer's solution, and an isotonic aqueous saline solution. The  
10       formulations are prepared by dissolving or suspending the active ingredient in the liquid carrier such that the final formulation contains from 0.005 to 10% by weight of the active ingredient. Other additives including a preservative, an isotonizer, a solubilizer, a stabilizer and a pain-soothing agent may adequately be employed.

15           The compounds of the present invention can also be administered in the form of liposome delivery systems, such as small unilamellar vesicles, large unilamellar vesicles and multilamellar vesicles. Liposomes containing delivery systems as well known in the art are formed from a variety of phospholipids,  
20       such as cholesterol, stearylamine or phosphatidylcholines.

          As used herein, a "therapeutically effective amount" of the instant pharmaceutical composition, or compound therein, means an amount that inhibits the function of the kinase enzymatic activity. The instant  
25       pharmaceutical composition will generally contain a per dosage unit (e.g., tablet, capsule, powder, injection, teaspoonful and the like) from about 0.001 to about 100 mg/kg. In one embodiment, the instant pharmaceutical composition contains a per dosage unit of from about 0.01 to about 50 mg/kg of compound, and preferably from about 0.05 to about 20 mg/kg. Methods are known in the art  
30       for determining therapeutically effective doses for the instant pharmaceutical composition. The effective dose for administering the pharmaceutical composition to a human, for example, can be determined mathematically from the results of animal studies. Furthermore, compounds of the present invention can be administered in intranasal form via topical use of suitable intranasal

vehicles, or via transdermal routes, using those forms of transdermal skin patches well known to those of ordinary skill in that art. To be administered in the form of a transdermal delivery system, the dosage administration will, of course, be continuous rather than intermittent throughout the dosage regimen.

5

#### Oral dosage forms

Because of their ease of administration, tablets and capsules represent an advantageous oral dosage unit form, wherein solid pharmaceutical carriers are employed. If desired, tablets may be sugar-coated or enteric-coated by standard techniques.

10

For liquid forms the active drug component can be combined in suitably flavored suspending or dispersing agents such as the synthetic and natural gums, for example, tragacanth, acacia, methyl-cellulose and the like. Other dispersing agents that may be employed include glycerin and the like.

15

#### Skin Care Compositions

In one embodiment of the present invention, compounds of the present invention are formulated as skin care compositions, particularly for use in treating psoriasis.

20

Skin care compositions of the present invention preferably comprise, in addition to the active compound of the present invention, a cosmetically- or pharmaceutically-acceptable carrier.

25

Herein, "cosmetically-acceptable carrier" means one or more compatible solid or liquid filler diluents or encapsulating substances which are suitable for use in contact with the skin of humans and lower animals without undue toxicity, incompatibility, instability, irritation, allergic response, and the like, commensurate with a reasonable benefit/risk ratio.

30

Herein, "compatible" means that the components of the cosmetic or pharmaceutical compositions are capable of being commingled with the active compound of the present invention, and with each other, in a manner such that

there is no interaction which would substantially reduce the cosmetic or pharmaceutical efficacy of the composition under ordinary use situations.

Preferably the skin care compositions of the present invention are topical compositions., ie., they are applied topically by the direct laying on or spreading of the composition on skin. Preferably such topical compositions comprise a cosmetically- or pharmaceutically-acceptable topical carrier.

The topical composition may be made into a wide variety of product types. These include, but are not limited to, lotions, creams, beach oils, gels, sticks, sprays, ointments, pastes, mousses, and cosmetics; hair care compositions such as shampoos and conditioners; and personal cleansing compositions.

Preferably the carrier is a cosmetically- or pharmaceutically-acceptable aqueous or organic solvent. Water is a preferred solvent. Examples of suitable organic solvents include: propylene glycol, polyethylene glycol (200-600), polypropylene glycol (425-2025), propylene glycol-14 butyl ether, glycerol, 1,2,4butanetriol, sorbitol esters, 1,2,6-hexanetriol, ethanol, isopropanol, butanediol, and mixtures thereof. Such solutions useful in the present invention preferably contain from about 0.001% to about 25% of the active compound, more preferably from about 0.1% to about 10% more preferably from about 0.5% to about 5%; and preferably from about 50% to about 99.99% of an acceptable aqueous or organic solvent, more preferably from about 90% to about 99%.

25

Skin care compositions of the present invention may further include a wide variety of additional oil-soluble materials and/or water-soluble materials conventionally used in topical compositions, at their art-established levels. Such additional components include, but are not limited to: thickeners, pigments, fragrances, humectants, proteins and polypeptides, preservatives, pacifiers, penetration enhancing agents, collagen, hylauronic acid, elastin, hydrolysates, primrose oil, jojoba oil, epidermal growth factor, soybean saponins, mucopolysaccharides, Vitamin A and derivatives thereof, Vitamin B2, biotin, pantothenic acid, Vitamin D, and mixtures thereof.

### Inhalant compositions

In a particular embodiment, the instant pharmaceutical composition is administered by inhalation. For inhalation therapy, the composition may be in a solution useful for administration by metered dose inhalers, or in a form suitable for a dry powder inhaler or insufflator. More particularly, the instant composition is conveniently delivered in the form of an aerosol spray delivered, for example from a pressurized container, a pack or a nebuliser, with the use of a suitable propellant, e.g., dichlorodifluoromethane, trichlorofluoromethane, dichlorotetrafluoroethane, carbon dioxide or other suitable gas inside such container. The dosage unit may be determined by providing a valve to deliver a metered amount. Capsules and cartridges made of a pharmaceutically acceptable material such as gelatin for use in an inhaler or insufflator may be formulated containing a powder mix of the compound and a suitable powder base such as lactose or starch.

### Coadministration Of Pharmaceutical Agents

In a preferred embodiment of this invention, VEGF-R selective agents of the present invention are advantageously co-administered with at least one other anti-tumor agent to facilitate eradication or stasis of a malignancy. For example, but not to limit the present invention, an anti-VEGF-R compound of the present invention, acting, for example, as anti-angiogenic compound, can be administered in a dosing regimen with a cytotoxic compound, such as a DNA alkylating agent. Preferred anti-tumor agents are selected from the group consisting of cladribine (2-chloro-2'-deoxy-(beta)-D-adenosine), Chlorambucil (4-[bis(2-chlorethyl)amino]benzenebutanoic acid), DTIC-Dome (5-(3,3-dimethyl-1-triazeno)-imidazole-4-carboxamide), platinum chemotherapeutics and nonplatinum chemotherapeutics. Platinum containing anti-tumor agents include, but are not limited to, cisplatin (cis-dichlorodiamineplatinum). Non-platinum containing anti-tumor agents include, but are not limited to, cyclophosphamide, fluorouracil, epirubicin, methotrexate, vincristine, doxorubicin, bleomycin, and etoposide. Each anti-tumor agent is administered within therapeutically effective amounts, which are well known in the art, and vary based on the agent used, the type of malignancy, and other conditions

### Specific Synthetic Examples

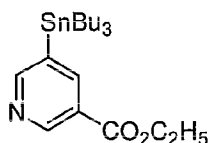
The invention can be better understood by way of the following examples. These examples are representative of the preferred embodiments, but  
5 are not to be construed as limiting the scope of the invention.

### General

<sup>1</sup>H NMR spectra were measured on a Bruker AC-300 (300 MHz) spectrometer using tetramethylsilane as an internal standard. Elemental analyses  
10 were obtained by Quantitative Technologies Inc. (Whitehouse, New Jersey), and the results were within 0.4% of the calculated values unless otherwise mentioned. Melting points were determined in open capillary tubes with a Thomas-Hoover apparatus and were uncorrected. Optical rotations were measured at 25 °C with an Autopol III polarimeter. Electrospray mass spectra  
15 (MS-ES) were recorded on a Hewlett Packard 59987A spectrometer. High resolution mass spectra (HRMS) were obtained on a Micromass Autospec. E. spectrometer.

### EXAMPLE 1

#### 20                      Synthesis of Intermediate Compound 1B



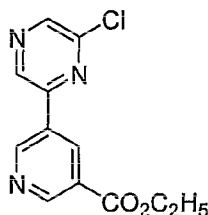
A mixture of 5-bromonicotinate (25 g, 108.7 mmol), bis(tributyltin) (63.05 g, 108.7 mmol), palladium acetate (1.1 g, 4.89 mmol), tri-*o*-tolylphosphine (8.6 g, 28.26 mmol) and triethylamine (21.96 g, 217.4 mmol) in  
25 acetonitrile (350 mL) was stirred at 95-100 °C for 22 h under nitrogen. The cooled reaction mixture was filtered through celite. Then the celite was washed with more acetonitrile and the combined acetonitrile was concentrated under vacuum. The residue was diluted with a suitable solvent, such as dichloromethane, washed with aqueous sodium carbonate and concentrated. The  
30 residue was further diluted with hexane. The solid was filtered off and the filtrate was concentrated. The product was purified by column chromatography (twice, SiO<sub>2</sub>, dichloromethane/hexane as solvent) to give 19.09 g (40%) of **1B** as

a light orange oil;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.11 (brs, 1 H), 8.74 (brs, 1 H), 8.35 (brs, 1 H), 4.41 (q,  $J = 6.9$  Hz, 2 H), 1.72-1.05 (m, 21 H), 0.89 (t,  $J = 7.2$  Hz, 9 H); MS (ES)  $m/z$ : 442 ( $\text{M}+\text{H}^+$ ).

5

## EXAMPLE 2

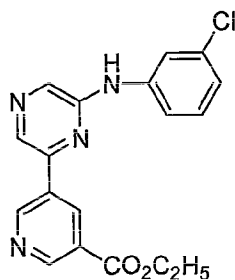
## Synthesis of Intermediate Compound 1D



A mixture of **1B** (10 g, 22.7 mmol), 2, 6-dichloropyrazine (6.76 g, 45.4 mmol), dichloro-bis(triphenylphosphine)palladium (797 mg, 1.14 mmol) and  
10 LiCl (4.77 g, 113.5 mmol) in anhydrous toluene (85 mL) was stirred at 100 °C for 23 h under nitrogen. The cooled reaction mixture was concentrated under vacuum. Aqueous sodium carbonate was added to the residue and stirred for 10 min. and extracted with dichloromethane (3x). The combined dichloromethane solution was filtered through celite, dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. The  
15 product was purified by column chromatography (EtOAc/hexane as solvent) to give 3.56 g (60%) of **1D** as an off-white solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.43 (brs, 1 H), 9.35 (brs, 1 H), 9.05 (s, 1 H), 8.91 (s, 1 H), 8.64 (s, 1 H), 4.48 (q,  $J = 7.3$  Hz, 2 H), 1.47 (t,  $J = 7.2$  Hz, 3 H); MS (ES)  $m/z$ : 264 ( $\text{M}+\text{H}^+$ ). Anal. Calcd. For  $\text{C}_{12}\text{H}_{10}\text{N}_3\text{O}_2\text{Cl}$ : C, 54.66; H, 3.82; N, 15.94. Found: C, 54.62; H, 3.77; N, 15.57.  
20

## EXAMPLE 3

## COMPOUND 1



25 A mixture of **1D** (24.3 g, 92.4 mmol), 3-chloroaniline (16.6 g, 129 mmol),  $\text{Pd}_2(\text{dba})_3$  (2.39 g, 2.31 mmol), DPPF (4.1 g, 7.4 mmol),  $\text{Cs}_2\text{CO}_3$  (60.2 g,

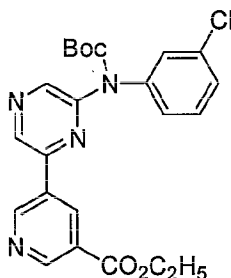


185 mmol) in anhydrous dioxane (230 mL) was stirred at 110 °C for 46 h under nitrogen. Dichloromethane (100 mL) was added to the cooled reaction mixture. The mixture was then filtered through celite, the celite cake was washed with more dichloromethane and the combined filtrate was concentrated to give a  
5 yellow-brown solid. Small amounts of dichloromethane was added, the solid was collected through filtration and the filtrate was concentrated. The solid collected was recrystallized from EtOAc/hexane to give 21.83 g (67%) of **Cmd 1** as a yellow solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.44 (brs, 1 H), 9.31 (brs, 1 H), 8.90 (s, 1 H), 8.57 (s, 1 H), 8.26 (s, 1 H), 7.72 (s, 1 H), 7.44 (d, J = 8.1 Hz, 1 H),  
10 7.31 (t, J = 8.0 Hz, 1 H), 7.08 (d, J = 8.0 Hz, 1 H), 7.04 (s, 1 H), 4.48 (q, J = 7.2 Hz, 2 H), 1.46 (t, J = 7.0 Hz, 3 H); MS (ES) m/z: 355 (M+H<sup>+</sup>). Anal. Calcd. For C<sub>18</sub>H<sub>15</sub>N<sub>4</sub>O<sub>2</sub>Cl: C, 60.94; H, 4.26; N, 15.79 Found: C, 60.54; H, 4.33; N, 15.58.

## EXAMPLE 4

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## COMPOUND 2



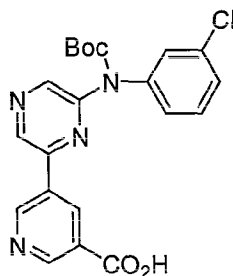
A mixture of **Cmd 1** (21.83 g, 61.7 mmol), Boc<sub>2</sub>O (26.9 g, 123 mmol), and DMAP (~3 g, cat.) in dichloromethane (500 mL) was stirred at 20 °C for 4 h. The reaction mixture was concentrated and the product was purified by column  
20 chromatography (EtOAc/hexane as solvent) to give 26.7 g (95%) of **Cmd 2** as yellowish oil; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.22 (d, J = 2.0 Hz, 1 H), 9.15 (d, J = 2.2 Hz, 1 H), 9.10 (s, 1 H), 8.84 (s, 1 H), 8.64 (t, J = 2.1 Hz, 1 H), 7.35 (m, 3 H), 7.18 (brd, J = 7.3 Hz, 1 H), 4.44 (q, J = 7.1 Hz, 2 H), 1.50 (s, 9 H), 1.44 (t, J = 7.1 Hz, 3 H); MS (ES) m/z: 455 (M+H<sup>+</sup>).

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## EXAMPLE 5

## COMPOUND 3

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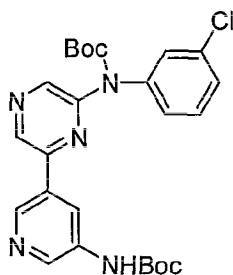


Compound **Cmd 2** (32.2 g, 71 mmol) was dissolved in methanol (200 mL) and stirred for 10 min then cooled to 0 °C. A NaOH<sub>(aq)</sub> (1 N, 118 mL) solution was added slowly and the mixture was stirred at 0 °C for 20 min then  
 5 stirred at 20 °C for another 18 h. Glacial acetic acid (95 mL) was added to the reaction mixture at 0 °C slowly followed by the addition of water (350 mL). A yellow solid was formed. The yellow solid was collected through filtration, washed with water (5x), dried in vacuum oven overnight to give 28.3 g (94%) of the carboxylic acid **Cmd 3** as a yellow solid; <sup>1</sup>H NMR (300 MHz, D<sup>6</sup>-DMSO) δ  
 10 9.27 (d, J = 1.9 Hz, 1 H), 9.22 (s, 1 H), 9.09 (d, J = 1.6 Hz, 1 H), 9.03 (s, 1 H), 8.65 (brs, 1 H), 7.52-7.31 (m, 4 H), 1.44 (s, 9 H); MS (ES) m/z: 425 (M-H<sup>+</sup>).  
 Anal. Calcd. For C<sub>21</sub>H<sub>19</sub>N<sub>4</sub>O<sub>4</sub>Cl: C, 59.09; H, 4.49; N, 13.13. Found: C, 58.82; H, 4.38; N, 12.98.

15

## EXAMPLE 6

## COMPOUND 67



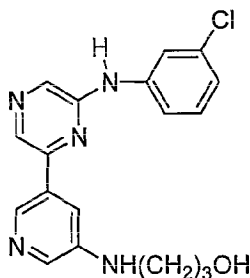
A mixture of the carboxylic acid **Cmd 3** (28.3 g, 66.5 mmol), DPPA (21.95 g, 80 mmol), triethylamine (13.43 g, 133 mmol), t-BuOH (280 mL) in  
 20 toluene (200 mL) was stirred under nitrogen at 70 °C for 30 min then stirred at 100 °C for 4 h. The reaction mixture was concentrated under vacuum. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 29.28 g (89%) of **Cmd 67** as a yellowish foam; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.99 (s, 1 H), 8.80 (s, 1 H), 8.67 (d, J = 1.7 Hz, 1 H), 8.49 (d, J = 2.4

Hz, 1 H), 8.41 (brs, 1 H), 7.29 (m, 3 H), 7.17 (d,  $J = 7.5$  Hz, 1 H), 7.08 (s, 1 H), 1.54 (s, 9 H), 1.49 (s, 9 H); MS (ES)  $m/z$ : 498 ( $M+H^+$ ). Anal. Calcd. For  $C_{25}H_{28}N_5O_4Cl$ : C, 60.30; H, 5.67; N, 14.06. Found: C, 60.14; H, 5.49; N, 13.91.

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## EXAMPLE 7

## COMPOUND 4



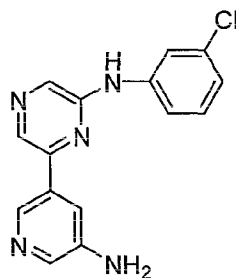
3-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-  
3-pyridinyl]amino]-1-propanol (Cmd 4)

10 A mixture of Cmd 67 (3 g, 6 mmol), (3-bromopropoxy)-*t*-butyl-dimethylsilane (2.28 g, 9 mmol) and  $Cs_2CO_3$  (5.9 g, 18 mmol) in DMF (60 mL) was stirred at 70 °C under nitrogen for 36 h. The reaction mixture was diluted with water, extracted with ether (3x), dried ( $Na_2SO_4$ ) and concentrated. The product was purified by column chromatography (EtOAc/hexane as solvent) to  
15 give 3.04 g of the silylated-product as orange oil. The silylated-product was dissolved in TFA (30 mL) and stirred at 20 °C for 1 h before it was concentrated. An ammonium hydroxide solution was added to the residue until the pH was about 10-11, water was added and a yellow solid was formed. The yellow solid was collected through filtration, washed with water and dried under vacuum.  
20 The yellow solid was recrystallized from  $CH_3OH/EtOAc$  to give 1.25 g (59%) of **Cmd 4** as a light yellow solid;  $^1H$  NMR (300 MHz,  $CD_3OD$ )  $\delta$  8.45 (s, 1 H), 8.41 (d,  $J = 1.6$  Hz, 1 H), 8.12 (brs, 2 H), 8.00 (d,  $J = 2.7$  Hz, 1 H), 7.66 (brs, 1 H), 7.55 (d,  $J = 8.3$  Hz, 1 H), 7.30 (t,  $J = 8.1$  Hz, 1 H), 6.99 (d,  $J = 7.9$  Hz, 1 H), 3.72 (t,  $J = 6.3$  Hz, 2 H), 3.33 (t,  $J = 6.8$  Hz, 2 H), 1.91 (m, 2 H); MS (ES)  $m/z$ :  
25 356 ( $M+H^+$ ). Anal. Calcd. For  $C_{18}H_{18}N_5OCl \cdot 0.5 H_2O$ : C, 59.26; H, 5.25; N, 19.20. Found: C, 59.30; H, 4.95; N, 18.95.

## EXAMPLE 8

## COMPOUND 5

58



6-(5-amino-3-pyridinyl)-

*N*-(3-chlorophenyl)- 2-pyrazinamine (**Cmd 5**)

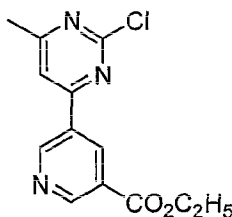
Compound **Cmd 67** (100 mg, 0.2 mmol) was dissolved in TFA (2 mL)

5 and stirred at 20 °C for 2 hours before it was concentrated. An ammonium hydroxide solution was added to the residue until the pH was about 10-11, water was added and a yellow solid was formed. The yellow solid was collected through filtration, washed with water and dried under vacuum to give 54 mg (91%) of **Cmd 5** as a light yellow solid; MS (ES) *m/z*: 298 (*M*+*H*<sup>+</sup>).

10

## EXAMPLE 9

## COMPOUND 6

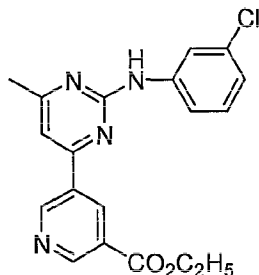


A mixture of Compound **1B** (500 mg, 1.14 mmol), 2, 4-dichloro-6-  
 15 methylpyrimidine (as in **Scheme 5**, Alternate Substitution Pattern #1, to replace Compound **1C**, where R<sub>3</sub> is methyl) (370 mg, 2.27 mmol), dichloro-bis(triphenylphosphine)palladium (40 mg, 0.057 mmol) and LiCl (239 mg, 5.68 mmol) in anhydrous toluene (5 mL) was stirred at 100 °C for 23 h under nitrogen. The cooled reaction mixture was concentrated under vacuum.  
 20 Aqueous sodium carbonate was added to the residue and stirred for 10 min. then extracted with dichloromethane (3x). The combined dichloromethane solution was filtered through celite, dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 281 mg (52%) of **Cmd 6** as an off-white solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.43 (d, J = 1.9 Hz, 1 H), 9.35 (d, J = 1.4 Hz, 1 H), 8.92 (d, J = 1.5 Hz, 1 H), 7.60 (s, 1 H),  
 25 4.48 (q, J = 7.1 Hz, 2 H), 2.66 (s, 3 H), 1.46 (t, J = 7.0 Hz, 3 H); MS (ES) *m/z*:

278 (M+H<sup>+</sup>).

# EXAMPLE 10

## COMPOUND 7



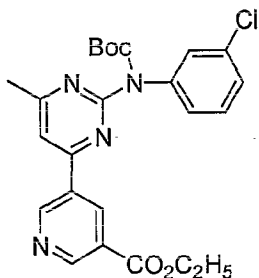
5

A mixture of **Cmd 6** (1.41 g, 5.09 mmol), 3-chloroaniline (782 mg, 6.11 mmol), Pd<sub>2</sub>(dba)<sub>3</sub> (132 mg, 0.127 mmol), DPPF (226 mg, 0.407 mmol), Cs<sub>2</sub>CO<sub>3</sub> (3.32 g, 10.2 mmol) in anhydrous dioxane (15 mL) was stirred at 110 °C for 26 h under nitrogen. Dichloromethane (30 mL) was added to the cooled reaction mixture which was then filtered through celite and the celite cake was washed with more dichloromethane. The combined filtrate was concentrated to give a yellow-brown solid. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 1.03 g (55%) of **Cmd 7** as a yellow-brown solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.44 (d, J = 2.1 Hz, 1 H), 9.32 (d, J = 1.9 Hz, 1 H), 8.91 (m, 1 H), 7.93 (t, J = 1.9 Hz, 1 H), 7.51 (d, J = 8.2 Hz, 1 H), 7.28 (m, 2 H), 7.16 (s, 1 H), 7.03 (d, J = 7.9 Hz, 1 H), 4.48 (q, J = 7.1 Hz, 2 H), 2.54 (s, 3 H), 1.46 (t, J = 7.1 Hz, 3 H); MS (ES) m/z: 369 (M+H<sup>+</sup>). Anal. Calcd. For C<sub>19</sub>H<sub>17</sub>N<sub>4</sub>O<sub>2</sub>Cl: C, 61.88; H, 4.65; N, 15.19. Found: C, 61.74; H, 4.63; N, 14.79.

20

# EXAMPLE 11

## COMPOUND 8

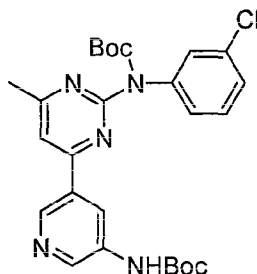


A mixture of **Cmd 7** (1 g, 2.72 mmol), Boc<sub>2</sub>O (3.56 g, 16.29 mmol), and DMAP (0.3 g, cat.) in dichloromethane (90 mL) was stirred at 20 °C for 24 h.

The reaction mixture was concentrated and the product was purified by column chromatography (EtOAc/hexane as solvent) to give 1.16 g (91%) of **Cmd 8** as a yellow brown foam;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.34 (d,  $J = 2.2$  Hz, 1 H), 9.30 (d,  $J = 2.0$  Hz, 1 H), 8.82 (m, 1 H), 7.46 (s, 1 H), 7.32-7.18 (m, 4 H), 4.46  
5 (q,  $J = 7.1$  Hz, 2 H), 2.60 (s, 3 H), 1.49 (s, 9 H), 1.44 (t,  $J = 7.1$  Hz, 3 H); MS (ES)  $m/z$ : 469 ( $\text{M}+\text{H}^+$ ), 369 ( $\text{M}+\text{H}^+ - \text{Boc}$ ).

## EXAMPLE 12

## COMPOUND 9

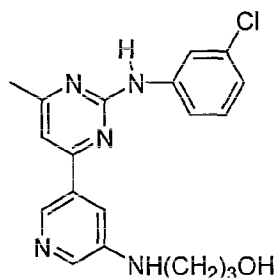


10

Compound **Cmd 8** (1.16 g, 2.49 mmol) was dissolved in methanol (30 mL) and stirred for 10 min then cooled to 0 °C. A  $\text{NaOH}_{(\text{aq})}$  (1 N, 18 mL) solution was added slowly and the mixture was stirred at 0 °C for 20 min then stirred at 20 °C for another 18 h. Glacial acetic acid (16 mL) was added to the  
15 reaction mixture at 0 °C slowly followed by the addition of water (200 mL). A yellowish-white solid was formed. The yellowish-white solid was collected through filtration, and washed with water (5x) then dried in vacuum oven overnight to give 1.04 g (95%) of **Cmd 63** as a light-brown solid; MS (ES)  $m/z$ : 439 ( $\text{M}-\text{H}^+$ ). Anal. Calcd. For  $\text{C}_{22}\text{H}_{21}\text{N}_4\text{O}_4\text{Cl}\cdot 0.5 \text{H}_2\text{O}$ : C, 58.73; H, 4.93; N, 12.45. Found: C, 59.04; H, 4.88; N, 12.23. A mixture of **Cmd 63** (1.02 g, 2.32  
20 mmol), DPPA (766 mg, 2.78 mmol), triethylamine (398 mg, 3.9 mmol), and t-BuOH (10 mL) in toluene (8 mL) was stirred under nitrogen at 70 °C for 30 min then stirred at 100 °C for 18 h. The reaction mixture was concentrated under vacuum. The product was purified by column chromatography (EtOAc/hexane  
25 as solvent) to give 883 mg (75%) of **Cmd 9** as a yellowish foam;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  8.86 (d,  $J = 1.4$  Hz, 1 H), 8.55 (m, 2 H), 7.42 (s, 1 H), 7.27 (m, 4 H), 6.80 (brs, 1 H), 2.58 (s, 3 H), 1.54 (s, 9 H), 1.48 (s, 9 H); MS (ES)  $m/z$ : 512 ( $\text{M}+\text{H}^+$ ), 412 ( $\text{M}+\text{H}^+ - \text{Boc}$ ). Anal. Calcd. For  $\text{C}_{26}\text{H}_{30}\text{N}_5\text{O}_4\text{Cl}$ : C, 60.99; H, 5.91; N, 13.68. Found: C, 60.83; H, 5.92; N, 13.33.

### EXAMPLE 13

## COMPOUND 10



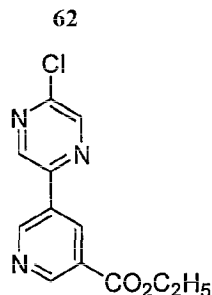
3-[[5-[2-[(3-chlorophenyl)amino]-6-methyl-4-pyrimidinyl]-3-pyridinyl]amino]-1-propanol (Cmd 10)

A mixture of **Cmd 9** (100 mg, 0.196 mmol), (3-bromopropoxy)-*t*-butyldimethylsilane (75 mg, 0.294 mmol) and  $\text{Cs}_2\text{CO}_3$  (192 mg, 0.59 mmol) in DMF (4 mL) was stirred at 70 °C under nitrogen for 24 h. The reaction mixture was diluted with water, extracted with ether (3x), dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 92 mg of the silylated-product as oil. The silylated-product was dissolved in TFA (4 mL) and stirred at 20 °C for 1 h before it was concentrated. An ammonium hydroxide solution was added to the residue until the pH was about 10-11, water was added and a yellow solid was formed. The yellow solid was collected through filtration, washed with water and dried under vacuum. The product was purified by column chromatography (dichloromethane/methanol as solvent), followed by recrystallization from EtOAc/hexane to give 36 mg (50%) of **Cmd 10** as an off-white solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CD}_3\text{OD}$ )  $\delta$  8.31 (s, 1 H), 7.98 (s, 1 H), 7.93 (s, 1 H), 7.43 (m, 2 H), 7.17 (m, 1 H), 7.00 (brs, 1 H), 6.89 (brd,  $J = 7.2$  Hz, 1 H), 3.72 (t,  $J = 6.2$  Hz, 2 H), 3.22 (m, 2 H), 2.34 (s, 3 H), 1.87 (m, 2 H); MS (ES)  $m/z$ : 370 ( $\text{M}+\text{H}^+$ ).

### EXAMPLE 14

COMPOUND 11

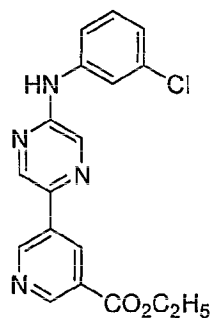
25



A mixture of **1B** (2 g, 4.54 mmol), 2, 3-dichloropyrazine (2.03 g, 13.62 mmol), dichloro-bis(triphenylphosphine)palladium (159 mg, 0.227 mmol) and LiCl (953 mg, 22.7 mmol) in anhydrous toluene (20 mL) was stirred at 100 °C for 23 h under nitrogen. The cooled reaction mixture was concentrated under vacuum. Aqueous sodium carbonate was added to the residue and stirred for 10 min. then extracted with dichloromethane (3x). The combined dichloromethane solution was filtered through celite, dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 648 mg (54%) of **Cmd 11** as an off-white solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.33 (d, J = 2.0 Hz, 1 H), 9.23 (d, J = 2.2 Hz, 1 H), 8.77 (t, J = 2.1 Hz, 1 H), 8.67 (d, J = 2.4 Hz, 1 H), 8.45 (d, J = 2.4 Hz, 1 H), 4.46 (q, J = 7.1 Hz, 2 H), 1.44 (t, J = 7.1 Hz, 3 H); MS (ES) m/z: 264 (M+H<sup>+</sup>). Anal. Calcd. For C<sub>12</sub>H<sub>10</sub>N<sub>3</sub>O<sub>2</sub>Cl: C, 54.66; H, 3.82; N, 15.94. Found: C, 54.78; H, 3.76; N, 15.54.

15

#### EXAMPLE 15 COMPOUND 12



A mixture of **Cmd 11** (567 mg, 2.15 mmol), 3-chloroaniline (359 mg, 2.8 mmol), Pd<sub>2</sub>(dba)<sub>3</sub> (56 mg, 0.054 mmol), DPPF (95 mg, 0.172 mmol), and Cs<sub>2</sub>CO<sub>3</sub> (1.4 g, 4.3 mmol) in anhydrous dioxane (7 mL) was stirred at 110 °C for 24 h under nitrogen. Dichloromethane (10 mL) was added to the cooled reaction mixture and filtered through celite. The celite cake was washed with more dichloromethane and the combined filtrate was concentrated. The product was

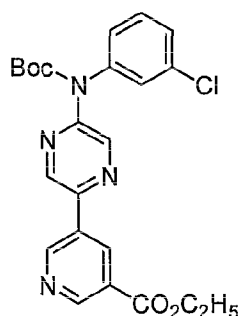
20



purified by column chromatography (EtOAc/hexane as solvent) followed by recrystallization from EtOAc/hexane to give 416 mg (55%) of **Cmd 12** as an off-white solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.31 (d,  $J = 2.0$  Hz, 1 H), 9.13 (d,  $J = 2.2$  Hz, 1 H), 8.65 (t,  $J = 2.1$  Hz, 1 H), 8.22 (m, 2 H), 7.67 (brs, 1 H), 7.26 (m, 2 H), 7.04 (m, 1 H), 6.63 (s, 1 H), 4.45 (q,  $J = 7.1$  Hz, 2 H), 1.43 (t,  $J = 7.1$  Hz, 3 H); MS (ES)  $m/z$ : 355 ( $\text{M}+\text{H}^+$ ). Anal. Calcd. For  $\text{C}_{18}\text{H}_{15}\text{N}_4\text{O}_2\text{Cl}$ : C, 60.94; H, 4.26; N, 15.79. Found: C, 61.07; H, 4.24; N, 15.60.

## EXAMPLE 16

## COMPOUND 13

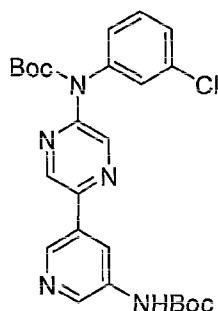


A mixture of **Cmd 12** (400 mg, 1.13 mmol),  $\text{Boc}_2\text{O}$  (493 mg, 2.26 mmol), and DMAP (20 mg, cat.) in dichloromethane (20 mL) was stirred at  $20^\circ\text{C}$  for 16 h. The reaction mixture was concentrated and the product was purified by column chromatography (EtOAc/hexane as solvent) to give 504 mg (98%) of **Cmd 13** as a yellowish oil;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.26 (d,  $J = 2.0$  Hz, 1 H), 9.12 (d,  $J = 2.2$  Hz, 1 H), 8.68 (m, 1 H), 8.64 (t,  $J = 2.1$  Hz, 1 H), 8.56 (d,  $J = 2.4$  Hz, 1 H), 7.21 (m, 3 H), 7.02 (brd,  $J = 7.9$  Hz, 1 H), 4.42 (q,  $J = 7.1$  Hz, 2 H), 1.39 (t,  $J = 7.1$  Hz, 3 H), 1.26 (s, 9 H); MS (ES)  $m/z$ : 455 ( $\text{M}+\text{H}^+$ ). Anal. Calcd. For  $\text{C}_{23}\text{H}_{23}\text{N}_4\text{O}_4\text{Cl}$ : C, 60.73; H, 5.10; N, 12.32. Found: C, 61.47; H, 5.29; N, 11.92.

## EXAMPLE 17

## COMPOUND 14

64



Compound **Cmd 13** (485 mg, 1.07 mmol) was dissolved in methanol (13 mL) and stirred for 10 min then cooled to 0 °C. A NaOH<sub>(aq)</sub> (1 N, 8 mL) solution was added slowly and the mixture was stirred at 0 °C for 20 min then

5 stirred at 20 °C for another 18 h. Glacial acetic acid (7 mL) was added to the reaction mixture at 0 °C slowly followed by the addition of water. A white solid was formed. The white solid was collected through filtration, and washed with water (3x), dried in vacuum oven overnight to give 262 mg (58%) of **Cmd 64** as an off-white solid; MS (ES) m/z: 425 (M-H<sup>+</sup>). A mixture of **Cmd 64** (262 mg,

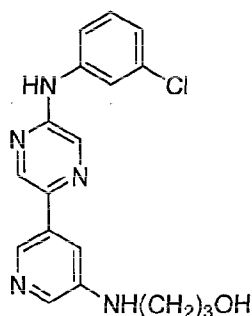
10 0.615 mmol), DPPA (203 mg, 0.74 mmol), triethylamine (106 mg, 1.05 mmol), and t-BuOH (2.7 mL) in toluene (2 mL) was stirred under nitrogen at 70 °C for 30 min then stirred at 100 °C for 4 h. The reaction mixture was concentrated under vacuum. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 224 mg (74%) of **Cmd 14** as a white foam;

15 <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.64 (d, J = 2.1 Hz, 2 H), 8.54 (d, J = 2.5 Hz, 1 H), 8.50 (d, J = 2.3 Hz, 1 H), 8.31 (brs, 1 H), 7.26-7.00 (m, 4 H), 6.57 (s, 1 H), 1.52 (s, 9 H), 1.27 (s, 9 H); MS (ES) m/z: 498 (M+H<sup>+</sup>). Anal. Calcd. For C<sub>25</sub>H<sub>28</sub>N<sub>5</sub>O<sub>4</sub>Cl: C, 60.30; H, 5.67; N, 14.06. Found: C, 60.69; H, 5.80; N, 13.73.

20

## EXAMPLE 18

## COMPOUND 15



3-[[5-[5-[(3-chlorophenyl)amino]pyrazinyl]-

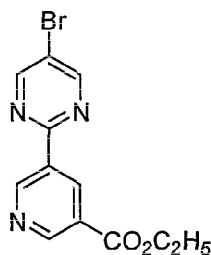
## 3-pyridinyl]amino]-1-propanol (Cmd 15)

A mixture of **Cmd 14** (82 mg, 0.165 mmol), (3-bromopropoxy)-t-butyl-dimethylsilane (63 mg, 0.248 mmol) and  $\text{Cs}_2\text{CO}_3$  (161 mg, 0.5 mmol) in DMF (3 mL) was stirred at 70 °C under nitrogen for 36 h. The reaction mixture was  
5 diluted with water, extracted with ether (3x), dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 73 mg of the silylated-product as oil. The silylated-product was dissolved in TFA (3 mL) and stirred at 20 °C for 1 hour before it was concentrated. An ammonium hydroxide solution was added to the residue until  
10 the pH was about 10-11. Water was added and a yellow-orange solid was formed. The yellow-orange solid was collected through filtration, washed with water and dried under vacuum. The product was purified by column chromatography (dichloromethane/methanol as solvent) to give 30 mg (51%) of **Cmd 15** as a light yellow oil;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  8.15 (brs, 2 H),  
15 8.08 (d,  $J = 2.6$  Hz, 1 H), 7.97 (d,  $J = 2.6$  Hz, 1 H), 7.72 (brs, 1 H), 7.33 (d,  $J = 8.2$  Hz, 1 H), 7.20 (m, 2 H), 7.09 (brs, 1 H), 6.99 (d,  $J = 7.9$  Hz, 1 H), 4.57 (m, 1 H), 3.77 (t,  $J = 5.6$  Hz, 2 H), 3.27 (m, 2 H), 1.86 (m, 2 H); MS (ES)  $m/z$ : 356 ( $\text{M}+\text{H}^+$ ). Anal. Calcd. For  $\text{C}_{18}\text{H}_{18}\text{N}_5\text{OCl}\cdot 0.2 \text{H}_2\text{O}$ : C, 60.15; H, 5.16; N, 19.48. Found: C, 60.09; H, 5.56; N, 19.45.

20

## EXAMPLE 19

## COMPOUND 16



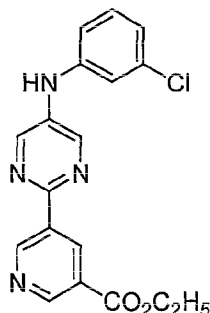
A mixture of **1B** (441 mg, 1 mmol), 5-bromo-2-iodopyrimidine (285 mg, 1 mmol), dichloro-bis(triphenylphosphine)palladium (35 mg, 0.05 mmol) and  
25 LiCl (210 mg, 5 mmol) in anhydrous toluene (5 mL) was stirred at 100 °C for 23 h under nitrogen. The cooled reaction mixture was concentrated under vacuum. Aqueous sodium carbonate was added to the residue and stirred for 10 min. then extracted with dichloromethane (3x). The combined dichloromethane solution  
30 was filtered through celite, dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. The product was

purified by column chromatography (EtOAc/hexane as solvent) to give 55 mg (18%) of **Cmd 16** as a yellow solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.76 (d,  $J = 2.1$  Hz, 1 H), 9.33 (d,  $J = 2.0$  Hz, 1 H), 9.24 (t,  $J = 2.1$  Hz, 1 H), 8.91 (s, 2 H), 4.46 (q,  $J = 7.1$  Hz, 2 H), 1.45 (t,  $J = 7.1$  Hz, 3 H); MS (ES)  $m/z$ : 310 ( $\text{M}+\text{H}^+$ ).

5

## EXAMPLE 20

## COMPOUND 17



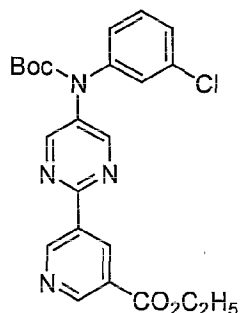
A mixture of **Cmd 16** (173 mg, 0.56 mmol), 3-chloroaniline (86 mg, 0.67 mmol),  $\text{Pd}_2(\text{dba})_3$  (14 mg, 0.014 mmol), DPPF (25 mg, 0.045 mmol), and  $\text{Cs}_2\text{CO}_3$  (365 mg, 1.12 mmol) in anhydrous dioxane (2 mL) was stirred at 110 °C for 23 h under nitrogen. Dichloromethane (20 mL) was added to the cooled reaction mixture. The mixture was filtered through celite. The celite cake with more dichloromethane and the combined filtrate was concentrated to give a yellow-brown solid. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 55 mg (27%) of **Cmd 17** as yellow solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.71 (d,  $J = 2.1$  Hz, 1 H), 9.27 (d,  $J = 2.0$  Hz, 1 H), 9.19 (t,  $J = 2.1$  Hz, 1 H), 8.66 (s, 2 H), 7.29 (m, 1 H), 7.15 (t,  $J = 1.9$  Hz, 1 H), 7.04 (m, 2 H), 5.90 (s, 1 H), 4.46 (q,  $J = 7.1$  Hz, 2 H), 1.45 (t,  $J = 7.1$  Hz, 3 H); MS (ES)  $m/z$ : 355 ( $\text{M}+\text{H}^+$ ).

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## EXAMPLE 21

## COMPOUND 18

67

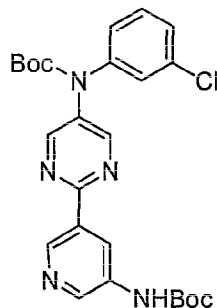


A mixture of **Cmd 17** (53 mg, 0.15 mmol),  $\text{Boc}_2\text{O}$  (195 mg, 0.89 mmol), and DMAP (5 mg, cat.) in dichloromethane (23 mL) was stirred at 20 °C for 4 h. The reaction mixture was concentrated and the product was purified by column chromatography (EtOAc/hexane as solvent) to give 59 mg (87%) of **Cmd 18** as a yellowish oil;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.75 (d,  $J = 2.0$  Hz, 1 H), 9.30 (d,  $J = 1.9$  Hz, 1 H), 9.23 (t,  $J = 2.0$  Hz, 1 H), 8.73 (s, 2 H), 7.33 (m, 3 H), 7.15 (brd,  $J = 7.6$  Hz, 1 H), 4.46 (q,  $J = 7.1$  Hz, 2 H), 1.51 (s, 9 H), 1.45 (t,  $J = 7.1$  Hz, 3 H); MS (ES)  $m/z$ : 455 ( $\text{M}+\text{H}^+$ ).

10

## EXAMPLE 22

## COMPOUND 19

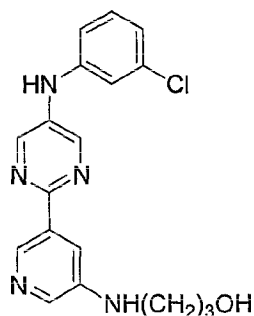


Compound **Cmd 18** (59 mg, 0.13 mmol) was dissolved in methanol (1.6 mL) and stirred for 10 min then cooled to 0 °C. A  $\text{NaOH}_{(\text{aq})}$  (1 N, 0.9 mL) solution was added slowly and the mixture was stirred at 0 °C for 20 min then stirred at 20 °C for another 18 h. Glacial acetic acid (0.9 mL) was slowly added to the reaction mixture at 0 °C followed by the addition of water (2 mL). A yellow solid was formed. The yellow solid was collected through filtration, washed with water (3x), dried in vacuum oven overnight to give 45 mg (81%) of **Cmd 65** as a yellow solid; MS (ES)  $m/z$ : 425 ( $\text{M}-\text{H}^+$ ). A mixture of **Cmd 65** (45 mg, 0.106 mmol), DPPA (35 mg, 0.127 mmol), triethylamine (18 mg, 0.18 mmol),  $t\text{-BuOH}$  (0.5 mL) in toluene (0.4 mL) was stirred under nitrogen at 70 °C

for 30 min then stirred at 100 °C for 4 h. The reaction mixture was concentrated under vacuum. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 40 mg (76%) of **Cmd 19** as a yellowish foam; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.28 (d, J = 1.7 Hz, 1 H), 8.90 (s, 1 H), 8.67 (s, 2 H), 8.65 (brs, 1 H), 7.41-7.12 (m, 5 H), 1.55 (s, 9 H), 1.50 (s, 9 H); MS (ES) m/z: 498 (M+H<sup>+</sup>).

## EXAMPLE 23

## COMPOUND 20



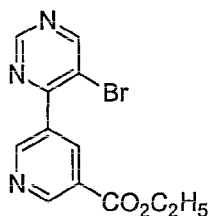
3-[[[5-[5-[(3-chlorophenyl)amino]-2-pyrimidinyl]-3-pyridinyl]amino]-1-propanol (**Cmd 20**)

A mixture of **Cmd 19** (39 mg, 0.078 mmol), (3-bromopropoxy)-t-butyl-dimethylsilane (30 mg, 0.117 mmol) and Cs<sub>2</sub>CO<sub>3</sub> (76 mg, 0.234 mmol) in DMF (2 mL) was stirred at 70 °C under nitrogen for 36 h. The reaction mixture was diluted with water, extracted with ether (3x), dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 34 mg of the silylated-product as oil. The silylated-product was dissolved in TFA (2 mL) and stirred at 20 °C for 2 hours before it was concentrated. An ammonium hydroxide solution was added to the residue until the pH was about 10-11, water was added and a yellow solid was formed. The yellow solid was collected through filtration, washed with water and dried under vacuum. The product was purified by column chromatography (dichloromethane/methanol as solvent) to give 18 mg (65%) of **Cmd 20** as a foam; <sup>1</sup>H NMR (300 MHz, D<sup>6</sup>-DMSO) δ 8.91 (s, 1 H), 8.71 (s, 2 H), 8.64 (brs, 1 H), 8.01 (d, J = 2.6 Hz, 1 H), 7.72 (brs, 1 H), 7.31 (t, J = 8.0 Hz, 1 H), 7.16 (s, 1 H), 7.14 (d, J = 8.2 Hz, 1 H), 6.97 (d, J = 7.0 Hz, 1 H), 6.04 (t, J = 5.3 Hz, 1 H), 4.55 (t, J = 5.1 Hz, 1 H), 3.53 (q, J = 5.4 Hz, 2 H), 3.14 (q, J = 5.9 Hz, 2 H), 1.74

(m, 2 H); MS (ES)  $m/z$ : 356 ( $M+H^+$ ). Anal. Calcd. For  $C_{18}H_{18}N_5OCl \cdot 0.5 H_2O$ : C, 59.26; H, 5.25; N, 19.20. Found: C, 59.49; H, 5.22; N, 18.97.

## EXAMPLE 24

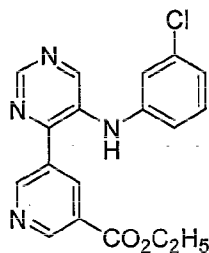
## COMPOUND 21



A mixture of **1B** (2.7 g, 6.1 mmol), 4-chloro-5-bromo-pyrimidine (2.71 g, 14.06 mmol), dichloro-bis(triphenylphosphine)palladium (428 mg, 0.61 mmol) and LiCl (1.28 g, 30.5 mmol) in anhydrous toluene (27 mL) was stirred at 100 °C for 23 h under nitrogen. The cooled reaction mixture was concentrated under vacuum. Aqueous sodium carbonate was added to the residue and stirred for 10 min, then extracted with dichloromethane (3x). The combined dichloromethane solution was filtered through celite, dried ( $Na_2SO_4$ ) and concentrated. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 303 mg (16%) of **Cmd 21** as an off-white solid;  $^1H$  NMR (300 MHz,  $CDCl_3$ )  $\delta$  9.35 (d,  $J = 2.0$  Hz, 1 H), 9.24 (m, 2 H), 9.00 (s, 1 H), 8.78 (t,  $J = 2.1$  Hz, 1 H), 4.46 (q,  $J = 7.1$  Hz, 2 H), 1.44 (t,  $J = 7.1$  Hz, 3 H); MS (ES)  $m/z$ : 310 ( $M+H^+$ ). Anal. Calcd. For  $C_{12}H_{10}N_3O_2Br$ : C, 46.77; H, 3.27; N, 13.64. Found: C, 46.86; H, 3.28; N, 13.56.

## EXAMPLE 25

## COMPOUND 22



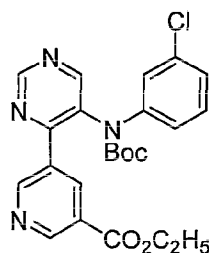
A mixture of **Cmd 21** (303 mg, 0.98 mmol), 3-chloroaniline (176 mg, 1.37 mmol),  $Pd_2(dba)_3$  (25 mg, 0.0245 mmol), DPPF (43 mg, 0.078 mmol), and  $Cs_2CO_3$  (639 mg, 1.96 mmol) in anhydrous dioxane (3 mL) was stirred at 110 °C

for 24 h under nitrogen. Dichloromethane (20 mL) was added to the cooled reaction mixture. The mixture was filtered through celite. The celite cake was washed with more dichloromethane and the combined filtrate was concentrated to give a yellow-brown solid. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 293 mg (84%) of **Cmd 22** as a yellow-brown foam;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.14 (brs, 2 H), 8.97 (d,  $J$  = 1.3 Hz, 1 H), 8.79 (s, 1 H), 8.67 (d,  $J$  = 1.5 Hz, 1 H), 7.19 (t,  $J$  = 8.4 Hz, 1 H), 6.99 (m, 2 H), 6.86 (brd,  $J$  = 8.0 Hz, 1 H), 6.21 (brs, 1 H), 4.40 (q,  $J$  = 7.1 Hz, 2 H), 1.40 (t,  $J$  = 7.1 Hz, 3 H); MS (ES)  $m/z$ : 355 ( $\text{M}+\text{H}^+$ ).

10

## EXAMPLE 26

## COMPOUND 23

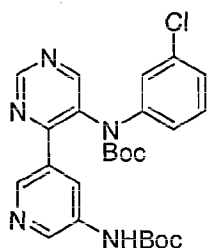


A mixture of **Cmd 22** (290 mg, 0.82 mmol),  $\text{Boc}_2\text{O}$  (560 mg, 257 mmol), and DMAP (20 mg, cat.) in dichloromethane (5 mL) was stirred at 20 °C for 24 h. The reaction mixture was concentrated and the product was purified by column chromatography (EtOAc/hexane as solvent) to give 349 mg (94%) of **Cmd 23** as a light-brown oil;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.27 (d,  $J$  = 2.0 Hz, 1 H), 9.26 (s, 1 H), 9.11 (d,  $J$  = 2.2 Hz, 1 H), 8.75 (s, 1 H), 8.61 (t,  $J$  = 2.1 Hz, 1 H), 7.13 (m, 3 H), 6.90 (brd,  $J$  = 7.8 Hz, 1 H), 4.42 (q,  $J$  = 7.1 Hz, 2 H), 1.39 (t,  $J$  = 7.1 Hz, 3 H), 1.33 (s, 9 H); MS (ES)  $m/z$ : 455 ( $\text{M}+\text{H}^+$ ).

25

## EXAMPLE 27

## COMPOUND 24

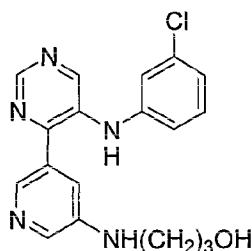




Compound **Cmd 23** (348 mg, 0.767 mmol) was dissolved in methanol (9.3 mL) and stirred for 10 min then cooled to 0 °C. A NaOH<sub>(aq)</sub> (1 N, 5.5 mL) solution was added slowly and the mixture was stirred at 0 °C for 20 min then stirred at 20 °C for another 2 h. Glacial acetic acid (5 mL) was slowly added to the reaction mixture at 0 °C followed by the addition of water (20 mL). A yellow solid was formed. The yellow solid was collected through filtration, and washed with water (2x), then dried in a vacuum oven overnight to give 336 mg (99%) of **Cmd 66** as a yellow solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.35 (d, J = 1.7 Hz, 1 H), 9.28 (s, 1 H), 9.18 (d, J = 2.1 Hz, 1 H), 8.78 (s, 1 H), 8.72 (t, J = 2.0 Hz, 1 H), 7.11(m, 3 H), 6.90 (brd, J = 7.4 Hz, 1 H), 1.35 (s, 9 H); MS (ES) m/z: 425 (M-H<sup>+</sup>). A mixture of **Cmd 66** (326 mg, 0.767 mmol), DPPA (253 mg, 0.92 mmol), triethylamine (132 mg, 1.3 mmol), and t-BuOH (3.3 mL) in toluene (2.5 mL) was stirred under nitrogen at 70 °C for 30 min then stirred at 100 °C for 4 h. The reaction mixture was concentrated under vacuum. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 310 mg (81%) of **Cmd 24** as a yellowish foam; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.22 (s, 1 H), 8.70 (s, 1 H), 8.58 (d, J = 1.9 Hz, 1 H), 8.52 (d, J = 2.4 Hz, 1 H), 8.34 (brs, 1 H), 7.16 (m, 3 H), 6.90 (d, J = 7.9 Hz, 1 H), 6.69 (s, 1 H), 1.52 (s, 9 H), 1.34 (s, 9 H); MS (ES) m/z: 498 (M+H<sup>+</sup>). Anal. Calcd. For C<sub>25</sub>H<sub>28</sub>N<sub>5</sub>O<sub>4</sub>Cl: C, 60.30; H, 5.67; N, 14.06. Found: C, 59.91; H, 5.70; N, 13.66.

## EXAMPLE 28

## COMPOUND 25



25 3-[[[5-[5-[(3-chlorophenyl)amino]-4-pyrimidinyl]-3-pyridinyl]amino]-1-propanol (**Cmd 25**)

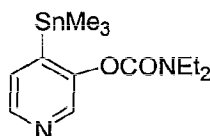
A mixture of **Cmd 24** (83 mg, 0.167 mmol), (3-bromopropoxy)-t-butyl-dimethylsilane (63 mg, 0.25 mmol) and Cs<sub>2</sub>CO<sub>3</sub> (163 mg, 0.5 mmol) in DMF (2 mL) was stirred at 70 °C under nitrogen for 36 h. The reaction mixture was diluted with water, extracted with ether (3x), dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated.

The product was purified by column chromatography (EtOAc/hexane as solvent) to give 92 mg of the silylated-product as an oil. The silylated-product was dissolved in TFA (2 mL) and stirred at 20 °C for 4 h before concentration. An ammonium hydroxide solution was added to the residue until the pH was about 10-11. Water was added and a yellow solid was formed. The yellow solid was collected through filtration, washed with water and dried under vacuum. The product was purified by column chromatography (dichloromethane/methanol as solvent) to give 30 mg (51%) of **Cmd 25** as a light yellow solid; <sup>1</sup>H NMR (300 MHz, CD<sub>3</sub>OD) δ 8.88 (s, 1 H), 8.75 (s, 1 H), 8.22 (d, J = 1.6 Hz, 1 H), 7.97 (d, J = 2.7 Hz, 1 H), 7.18 (m, 2 H), 7.03 (m, 2 H), 6.90 (dd, J = 7.7, 1.5 Hz, 1 H), 6.24 (s, 1 H), 4.40 (brt, J = 5.1 Hz, 1 H), 3.79 (t, J = 5.7 Hz, 2 H), 3.27 (q, J = 5.7 Hz, 2 H), 1.88 (m, 2 H); MS (ES) m/z: 356 (M+H<sup>+</sup>). Anal. Calcd. For C<sub>18</sub>H<sub>18</sub>N<sub>5</sub>OC1•0.4 H<sub>2</sub>O: C, 59.55; H, 5.22; N, 19.29. Found: C, 59.22; H, 5.36; N, 19.57.

15

## EXAMPLE 29

## Intermediate Compound 2C

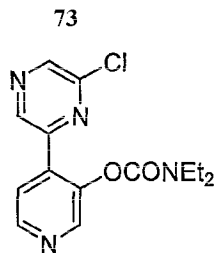


3-Pyridyl diethyl carbamate (1.0 g, 5.1 mmol, JACS 73 1210 1951) was dissolved in THF (10 mL) and was cooled to -78 °C. 1.3 M of sec BuLi (5.7 mmol) and TMEDA (0.66 g, 5.7 mmol) was added under nitrogen. The reaction mixture was stirred at -78 °C for 1 hour. Trimethyltin chloride (1.2 g, 6.2 mmol) in dry THF (5 mL) was added slowly and the reaction was warmed up to 20°C overnight. NH<sub>4</sub>Cl<sub>(aq)</sub> was added to quench the reaction and the product was extracted into EtOAc, dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated under vacuum. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 1.2 g (65%) of **2C** as a yellow oil; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.36 (m, 2 H), 7.38 (brt, J = 4.5 Hz, 1 H), 3.42 (m, 4 H), 1.24 (m, 6 H), 0.35 (s, 9 H); MS (ES) m/z: 359 (M+H<sup>+</sup>).

30

## EXAMPLE 30

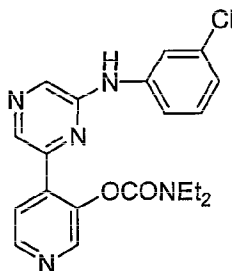
## Intermediate Compound 2D



A mixture of **2C** (0.11 g, 0.321 mmol), 2,6-dichloropyrazine (0.0478 g, 0.321 mmol), tris-2-furyl phosphine (0.015 g, 0.064 mmol), CuI (0.006 g, 0.032 mmol) and Pd<sub>2</sub>(dba)<sub>3</sub> (0.015 g, 0.016 mmol) in anhydrous NMP (1 mL) was stirred at 60 °C overnight under nitrogen. The cooled reaction mixture was concentrated under vacuum. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 0.06 g (64%) of **2D** as a solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.83 (s, 1 H), 8.60 (m, 3 H), 7.71 (d, J = 5.0 Hz, 1 H), 3.46 (q, J = 7.1 Hz, 2 H), 3.32 (q, J = 7.1 Hz, 2 H), 1.24 (t, J = 7.0 Hz, 3 H), 1.13 (t, J = 7.1 Hz, 3 H); MS (ES) m/z: 307 (M+H<sup>+</sup>).

### EXAMPLE 31

#### COMPOUND 27



4-[6-[(3-chlorophenyl)amino]pyrazinyl]-  
3-pyridinyl carbamic acid, diethyl-ester (**Cmd 27**)

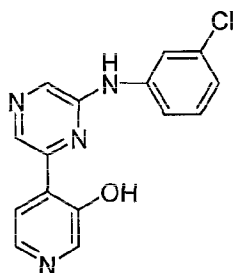
A mixture of **2D** (0.1 g, 0.326 mmol), 3-chloroaniline (0.05 g, 0.391 mmol), Pd<sub>2</sub>(dba)<sub>3</sub> (0.0085 g, 0.008 mmol), DPPF (0.015 g, 0.026 mmol), and Cs<sub>2</sub>CO<sub>3</sub> (0.21 g, 0.652 mmol) in anhydrous dioxane (2 mL) was stirred at 100 °C overnight under nitrogen. Dichloromethane (100 mL) was added to the cooled reaction mixture, then the mixture was filtered through celite. The celite cake was washed with more dichloromethane and the combined filtrate was concentrated to give a yellow solid. The solid was purified by column chromatography (EtOAc/hexane as solvent) to give 0.088 g (68%) of **Cmd 27** as a yellow solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.56 (d, J = 4.4 Hz, 2 H), 8.39 (s, 1 H), 8.08 (s, 1 H), 7.74 (d, J = 5.0 Hz, 1 H), 7.54 (t, J = 1.6 Hz, 1 H), 7.32 (d,

$J = 8.0$  Hz, 1 H), 7.23 (t,  $J = 8.0$  Hz, 1 H), 7.04 (m, 2 H), 3.46 (q,  $J = 7.0$  Hz, 2 H), 3.34 (q,  $J = 7.1$  Hz, 2 H), 1.24 (t,  $J = 7.0$  Hz, 3 H), 1.15 (t,  $J = 7.0$  Hz, 3 H); MS (ES)  $m/z$ : 398 ( $M+H^+$ ).

5

## EXAMPLE 32

## COMPOUND 28



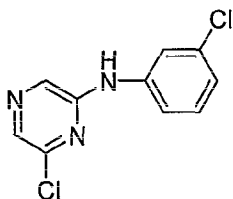
4-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinol (Cmd 28)

Cmd 27 (1.0 g, 2.5 mmol) was treated with absolute EtOH (50 mL) and 10% NaOH<sub>(aq)</sub> (50 mL). The reaction mixture was refluxed overnight. The solvent was removed and the residue was acidified with 1 N HCl and then basified back to pH = 10. A yellow suspension was formed. The product was extracted into CH<sub>2</sub>Cl<sub>2</sub> and dried (Na<sub>2</sub>SO<sub>4</sub>). Solvent was removed to give 0.4 g (53%) of Cmd 28 as a yellow solid; <sup>1</sup>H NMR (300 MHz, D<sup>6</sup>-DMSO)  $\delta$  9.90 (s, 1 H), 8.80 (s, 1 H), 8.35 (s, 1 H), 8.26 (s, 1 H), 8.19 (d,  $J = 4.4$  Hz, 1 H), 7.93 (brs, 1 H), 7.85 (d,  $J = 4.9$  Hz, 1 H), 7.56 (d,  $J = 7.3$  Hz, 1 H), 7.37 (t,  $J = 8.1$  Hz, 1 H), 7.05 (d,  $J = 9.1$  Hz, 1 H); MS (ES)  $m/z$ : 299 ( $M+H^+$ ).

20

## EXAMPLE 33

## COMPOUND 29

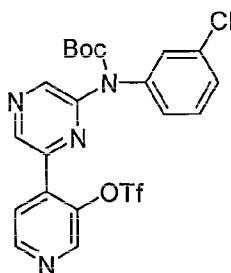


Palladium acetate (0.121 g, 0.537 mmol), BINAP (0.368 g 0.591 mmol), *t*-BuONa (3.609 g, 37.6 mmol), 2,6-dichloropyrazine (4 g, 26.85 mmol), 3-chloroaniline (3.44 g, 26.85 mmol) in toluene (100 mL) was stirred at 80 °C for 22 h under N<sub>2</sub>. CH<sub>2</sub>Cl<sub>2</sub> was added, the reaction mixture was filtered through celite and the solvent was evaporated. Product was purified by column

chromatography (EtOAc/hexane as solvent ) to give 5.8 g (90%) of **Cmd 29**;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  8.11 (s, 1 H), 8.03 (s, 1 H), 7.49 (s, 1 H), 7.30 (m, 2 H), 7.12 (m, 1 H), 6.60 (brs, 1 H); MS (ES)  $m/z$ : 241 ( $\text{M}+\text{H}^+$ ). Anal. Calcd. For  $\text{C}_{10}\text{H}_7\text{N}_3\text{Cl}\cdot 0.13\text{H}_2\text{O}$ : C, 49.54; H, 3.02; N, 17.33. Found: C, 49.38; H, 2.86; N, 17.22.

## EXAMPLE 34

## COMPOUND 30

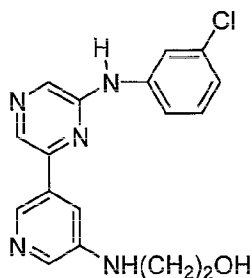


( $\text{CF}_3\text{SO}_2$ ) $_2\text{O}$  (0.12 g, 0.4 mmol) and triethylamine (0.04 g, 0.4 mmol) was added to a solution of **Cmd 28** (0.1 g, 0.33 mmol) in anhydrous  $\text{CH}_2\text{Cl}_2$  (5 mL) at 0 °C. The reaction was stirred under nitrogen at 20 °C for 8 h under  $\text{N}_2$ . The reaction mixture was concentrated under vacuum. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 0.072 g (51%) of triflate as an oil. The triflate was dissolved in  $\text{CH}_2\text{Cl}_2$  (2 mL), and treated with  $\text{Boc}_2\text{O}$  (0.041 g, 0.19 mmol) and DMAP (0.002 g, 0.019 mmol). The reaction mixture was stirred overnight at 20 °C under nitrogen. The solvent was removed under vacuum and the product was purified by column chromatography (EtOAc/Hex as solvent) to give 0.078 g (88%) of **Cmd 30** as an oil.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.16 (s, 1 H), 8.73 (s, 1 H), 8.68 (s, 1 H), 8.67 (d,  $J = 4.9$  Hz, 1 H), 7.49 (d,  $J = 5.0$  Hz, 1 H), 7.29 (m, 3 H), 7.14 (dt,  $J = 7.0, 2.0$  Hz, 1 H), 1.48 (s, 9 H); MS (ES)  $m/z$ : 531 ( $\text{M}+\text{H}^+$ ).

## EXAMPLE 35

## COMPOUND 31

76

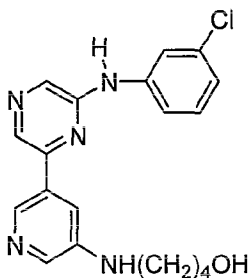


2-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-  
3-pyridinyl]amino]-ethanol (Cmd 31)

A mixture of **Cmd 67** (0.1 g, 0.2 mmol), (2-bromoethoxy)-*t*-butyl-  
5 dimethylsilane (0.07 g, 0.3 mmol) and  $\text{Cs}_2\text{CO}_3$  (0.197 g, 0.6 mmol) in DMF (4  
mL) was stirred at 70 °C under nitrogen for 22 h. The reaction mixture was  
diluted with water, extracted with ether (3x), dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated.  
The product was purified by column chromatography (EtOAc/hexane as solvent)  
to give 0.05 g of the silylated-product as an oil. The silylated-product was  
10 dissolved in TFA (1.5 mL) and stirred at 20 °C for 2 h before it was  
concentrated. An ammonium hydroxide solution was added to the residue until  
the pH was about 10-11 and a yellow solid was formed. The yellow solid was  
collected through filtration, washed with water and dried under vacuum to give  
0.029 g (43%) of **Cmd 31** as a light yellow solid;  $^1\text{H}$  NMR (300 MHz,  $\text{D}^6$ -  
15 DMSO)  $\delta$  9.87 (s, 1 H), 8.59 (s, 1 H), 8.46 (s, 1 H), 8.22 (s, 1 H), 8.12 (m, 2 H),  
7.61 (d,  $J = 8.2$  Hz, 1 H), 7.52 (s, 1H), 7.37 (t,  $J = 8.1$  Hz, 1 H), 7.03 (d,  $J = 7.8$   
Hz, 1 H), 6.10 (t,  $J = 5.3$  Hz, 1 H), 4.79 (t,  $J = 5.3$  Hz, 1 H), 3.63 (m, 2 H), 3.25  
(m, 2 H); MS (ES)  $m/z$ : 342 ( $\text{M}+\text{H}^+$ ).

20

#### EXAMPLE 36 COMPOUND 32



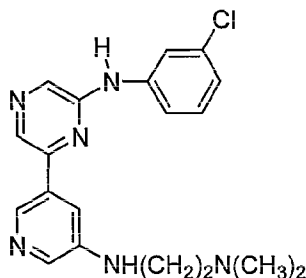
4-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-  
3-pyridinyl]amino]-1-butanol (Cmd 32)

A mixture of **Cmd 67** (0.034 g, 0.068 mmol), (4-bromobutoxy)-*t*-butyldimethylsilane (0.023 g, 0.1 mmol) and Cs<sub>2</sub>CO<sub>3</sub> (0.067 g, 0.2 mmol) in DMF (2 mL) was stirred at 70 °C under nitrogen for 5 days. The reaction mixture was diluted with water, extracted with ether (3x), dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated.

5 The product was purified by column chromatography (EtOAc/hexane as solvent) to give 0.037 g of the silylated-product as an oil. The silylated-product was dissolved in TFA (1.5 mL) and stirred at 20 °C for 2 h before it was concentrated. An ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a yellow solid was formed. The yellow solid was  
 10 collected through filtration, washed with water and dried under vacuum to give 0.016 g (64%) of **Cmd 32** as a light yellow solid; <sup>1</sup>H NMR (300 MHz, D<sup>6</sup>-DMSO) δ 9.88 (s, 1 H), 8.60 (s, 1 H), 8.45 (s, 1 H), 8.20 (m, 2 H), 8.08 (d, J = 2.5 Hz, 1 H), 7.56 (d, J = 8.2 Hz, 1 H), 7.48 (s, 1H), 7.36 (t, J = 8.0 Hz, 1 H), 7.03 (dd, J = 7.7, 1.4 Hz, 1 H), 6.12 (t, J = 5.2 Hz, 1 H), 4.45 (t, J = 5.1 Hz, 1 H),  
 15 3.44 (q, J = 6.1 Hz, 2 H), 3.15 (q, J = 6.2 Hz, 2 H), 1.59 (m, 4 H); MS (ES) m/z: 370 (M+H<sup>+</sup>).

## EXAMPLE 37

## COMPOUND 33



20

*N*<sup>1</sup>-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-

3-pyridinyl]-*N*<sup>2</sup>,*N*<sup>2</sup>-dimethyl-1,2-ethanediamine (**Cmd 33**)

A mixture of **Cmd 67** (0.05 g, 0.1 mmol), 2-

dimethylaminoethylchloride hydrochloride (0.022 g, 0.15 mmol) and Cs<sub>2</sub>CO<sub>3</sub>  
 25 (0.1 g, 0.3 mmol) in DMF (2 mL) and triethylamine (0.02 g 0.2 mmol) was stirred at 70 °C under nitrogen for 23 h. The reaction mixture was diluted with water, extracted with ether (3x), dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. The product was purified by column chromatography (CH<sub>2</sub>Cl<sub>2</sub>/MeOH as solvent) to give 0.025 g of the dimethylamino product as an oil. The dimethylamino-product

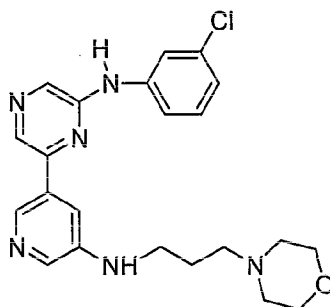
was dissolved in TFA (1.0 mL) and stirred at 20 °C for 2 hours before it was concentrated. An ammonium hydroxide solution was added to the residue until the pH was about 10-11. The product was extracted into CH<sub>2</sub>Cl<sub>2</sub>, washed with water and dried (Na<sub>2</sub>SO<sub>4</sub>). The product was further recrystallized from

5 CH<sub>2</sub>Cl<sub>2</sub>/Hexane to give 0.015 g (41%) of **Cmd 33** as a light yellow solid; <sup>1</sup>H NMR (300 MHz, CD<sub>3</sub>OD) δ 8.44 (m, 2 H), 8.13 (m, 2 H), 8.02 (d, J = 2.7 Hz, 1 H), 7.65 (m, 1 H), 7.52 (dd, J = 2.0, 0.9 Hz, 1 H), 7.29 (t, J = 8.0 Hz, 1 H), 7.00 (dd, J = 2.0, 0.9 Hz, 1 H), 3.36 (t, J = 6.5 Hz, 2 H), 2.64 (t, J = 6.5 Hz, 2 H), 2.32 (s, 6 H); MS (ES) m/z: 369 (M+H<sup>+</sup>).

10

## EXAMPLE 38

## COMPOUND 34



*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-

15

3-pyridinyl]-4-morpholinepropanamine (**Cmd 34**)

A mixture of **Cmd 67** (0.1 g, 0.2 mmol), morpholinopropyl chloride (0.049 g, 0.3 mmol) and Cs<sub>2</sub>CO<sub>3</sub> (0.197 g, 0.6 mmol) in DMF (4 mL) was stirred at 70 °C under nitrogen for 20 hours. The reaction mixture was diluted with water, extracted with ether (3x), dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. The product

20 was purified by column chromatography (CH<sub>2</sub>Cl<sub>2</sub>/MeOH as solvent) to give 0.1 g of product as a hard foam. The hard foam was dissolved in TFA (2.0 mL) and stirred at 20 °C for 2 h before it was concentrated. An ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a yellow solid was formed. The yellow solid was collected through filtration, washed

25 with water and dried under vacuum to give 0.053 g (62%) of **Cmd 34** as a yellow solid; <sup>1</sup>H NMR (300 MHz, CD<sub>3</sub>OD) δ 8.43 (s, 1 H), 8.39 (d, J = 1.5 Hz, 1 H), 8.16 (d, J = 1.9 Hz, 1 H), 8.09 (s, 1 H), 7.99 (d, J = 2.3 Hz, 1 H), 7.64 (s, 1 H), 7.47 (d, J = 7.8 Hz, 1 H), 7.27 (t, J = 8.0 Hz, 1 H), 6.98 (d, J = 7.9 Hz, 1 H),

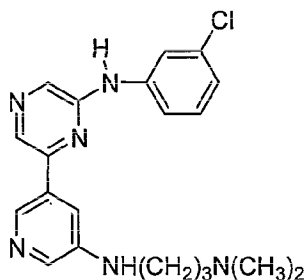


3.66 (m, 4 H), 3.28 (m, 2 H), 2.49 (m, 6 H), 1.85 (m, 2 H); MS (ES)  $m/z$ : 425 ( $M+H^+$ ). Anal. Calcd. For  $C_{22}H_{25}N_6OCl \cdot 0.55 H_2O$ : C, 60.77; H, 6.05; N, 19.33. Found: C, 60.81; H, 5.70; N, 19.00.

5

## EXAMPLE 39

## COMPOUND 35



$N^1$ -[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-

3-pyridinyl]- $N^3,N^3$ -dimethyl-1,3-propanediamine(Cmd 35)

10 A mixture of **Cmd 67** (0.15 g, 0.3 mmol), (3-chloro-N, N-dimethylpropylamine (0.071 g, 0.45 mmol) and  $Cs_2CO_3$  (0.3 g, 0.9 mmol) in DMF (6 mL) and triethylamine (0.06 g, 0.6 mmol) was stirred at 70 °C under nitrogen for 2 days. The reaction mixture was diluted with water, extracted with ether (3x), dried ( $Na_2SO_4$ ) and concentrated. The product was purified by column

15 chromatography ( $CH_2Cl_2$ /MeOH as solvent) to give 0.08 g of the dimethylamino product as an oil. The dimethylamino-product was dissolved in TFA (3.0 mL) and stirred at 20 °C for 1.5 h before concentration. An ammonium hydroxide solution was added to the residue until the pH was about 10-11. Water was added and the product was extracted into  $CH_2Cl_2$ , washed with water and dried

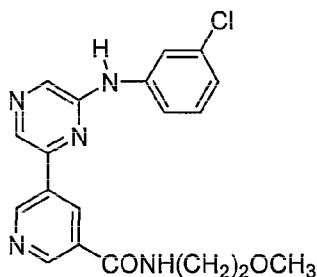
20 ( $Na_2SO_4$ ). The product was further recrystallized from  $CH_2Cl_2$ /hexane to give 0.047 g (43%) of **Cmd 35** as a light yellow solid;  $^1H$  NMR (300 MHz,  $CD_3OD$ )  $\delta$  8.42 (m, 2 H), 8.16 (t,  $J = 2.0$  Hz, 1 H), 8.10 (s, 1 H), 8.00 (d,  $J = 2.6$  Hz, 1 H), 7.63 (t,  $J = 2.0$  Hz, 1 H), 7.48 (dd,  $J = 7.5, 1.2$  Hz, 1 H), 7.28 (t,  $J = 8.0$  Hz, 1 H), 6.98 (dd,  $J = 7.2, 1.1$  Hz, 1 H), 3.27 (m, 2 H), 2.54 (brt,  $J = 7.5$  Hz, 2 H), 2.30 (s,

25 6 H), 1.88 (m, 2 H); MS (ES)  $m/z$ : 383 ( $M+H^+$ ). Anal. Calcd. For  $C_{20}H_{23}N_6OCl \cdot 0.9 H_2O$ : C, 60.19; H, 6.26; N, 21.06. Found: C, 60.40; H, 5.96; N, 20.68.

## EXAMPLE 40

## COMPOUND 36

80



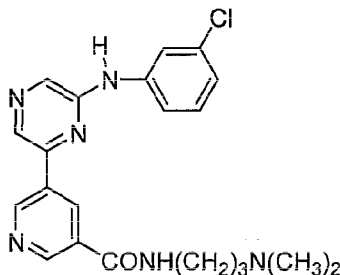
5-[6-[(3-chlorophenyl)amino]pyrazinyl]-

*N*-(2-methoxyethyl)-3-pyridinecarboxamide(Cmd 36)

A mixture of **Cmd 3** (0.05 g, 0.12 mmol), 2-methoxyethylamine (0.009 g, 0.12 mmol) diisopropylethylamine (0.06 g, 0.47 mmol) and HATU (0.045 g, 0.12 mmol) in DMF (2 mL) was stirred at 20 °C under N<sub>2</sub> overnight. Solvent was removed and product was purified by column chromatography (CH<sub>2</sub>Cl<sub>2</sub>/MeOH as solvent) to give 0.033 g of product as a solid. The above product was dissolved in TFA (2.0 mL) and stirred at 20 °C for 2 h before it was concentrated. An ammonium hydroxide solution was added to the residue until the pH was about 10-11, a light tan solid was formed. The tan solid was collected through filtration, washed with water and dried under vacuum to give 0.010 g (22%) of **Cmd 36** as a light tan solid; <sup>1</sup>H NMR (300 MHz, CD<sub>3</sub>OD) δ 9.36 (s, 1 H), 9.02 (s, 1 H), 8.85 (s, 1 H), 8.56 (s, 1 H), 8.16 (s, 1 H), 8.02 (s, 1 H), 7.59 (d, J = 8.0 Hz, 1 H), 7.30 (t, J = 8.0 Hz, 1 H), 7.02 (d, J = 7.9 Hz, 1 H), 3.62 (s, 4 H), 3.39 (s, 3 H); MS (ES) m/z: 384 (M+H<sup>+</sup>).

## EXAMPLE 41

## COMPOUND 37



5-[6-[(3-chlorophenyl)amino]pyrazinyl]-

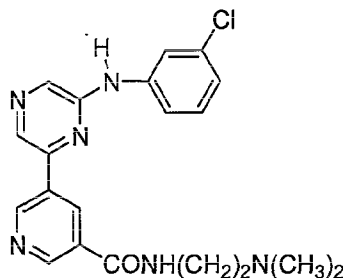
*N*-(3-methoxypropyl)-3-pyridinecarboxamide(Cmd 37)

A mixture of **Cmd 3** (0.075 g, 0.176 mmol), 3-dimethylaminopropylamine (0.018 g, 0.176 mmol) diisopropylethylamine (0.09

g, 0.69 mmol) and HATU (0.067 g, 0.176 mmol) in DMF (4 mL) was stirred at 20 °C under N<sub>2</sub> overnight. Solvent was removed and product was purified by column chromatography (CH<sub>2</sub>Cl<sub>2</sub>/MeOH/Acetic acid as solvent) to give 0.015 g of product. The above product was dissolved in TFA (2.0 mL) and stirred at 20 °C for 2 h before it was concentrated. An ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a yellow solid was formed. The yellow solid was collected through filtration, washed with water and dried under vacuum to give 0.009 g (13%) of **Cmd 37** as a yellow solid; <sup>1</sup>H NMR (300 MHz, CD<sub>3</sub>OD) δ 9.30 (s, 1 H), 9.02 (s, 1 H), 8.87 (s, 1 H), 8.59 (s, 1 H), 8.20 (s, 1 H), 8.08 (s, 1 H), 7.59 (d, J = 6.4 Hz, 1 H), 7.32 (t, J = 8.0 Hz, 1 H), 7.02 (d, J = 5.9 Hz, 1 H), 3.48 (t, J = 7.0 Hz, 2 H), 2.50 (brt, J = 7.9 Hz, 2 H), 2.31 (s, 6 H), 1.87 (m, 2 H); MS (ES) m/z: 411 (M+H<sup>+</sup>).

## EXAMPLE 42

## COMPOUND 38



5-[6-[(3-chlorophenyl)amino]pyrazinyl]-

*N*-[2-(dimethylamino)ethyl]-3-pyridinecarboxamide (**Cmd 38**)

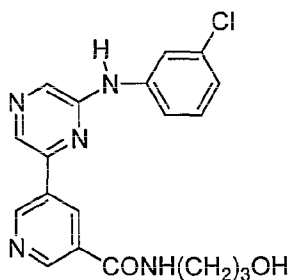
A mixture of **Cmd 3** (0.05 g, 0.12 mmol), *N,N*-dimethylethylenediamine (0.01 g, 0.12 mmol) diisopropylethylamine (0.06 g, 0.47 mmol) and HATU (0.045 g, 0.12 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (2 mL) was stirred at 20 °C under N<sub>2</sub> for 2 days. Solvent was removed and the product was purified by column chromatography (CH<sub>2</sub>Cl<sub>2</sub>/MeOH/Acetic acid as solvent) to give 0.02 g of product. The above product was dissolved in TFA (1.0 mL) and stirred at 20 °C for 1 h before concentration. An ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a yellow solid was formed. The yellow solid was collected through filtration, washed with water and dried under vacuum to give 0.005 g (11%) of **Cmd 38** as a yellow solid; <sup>1</sup>H NMR (300 MHz, CD<sub>3</sub>OD) δ 9.39 (s, 1 H), 9.06 (s, 1 H), 8.91 (s, 1 H), 8.59 (s, 1 H), 8.19 (s, 1 H), 8.07 (s, 1

H), 7.59 (d, J = 8.3 Hz, 1 H), 7.32 (t, J = 8.1 Hz, 1 H), 7.02 (d, J = 7.8 Hz, 1 H), 3.60 (t, J = 6.7 Hz, 2 H), 2.63 (t, J = 6.7 Hz, 2 H), 2.34 (s, 6 H) ; MS (ES) m/z: 397 (M+H<sup>+</sup>).

5

## EXAMPLE 43

## COMPOUND 39



5-[6-[(3-chlorophenyl)amino]pyrazinyl]-N-(3-hydroxypropyl)-  
3-pyridinecarboxamide (Cmd 39)

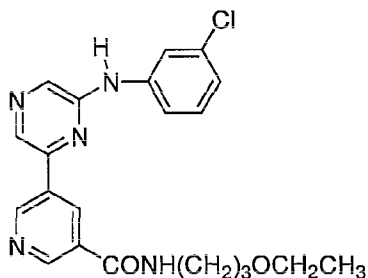
10 A mixture of **Cmd 3** (0.025 g, 0.06 mmol), 3-amino-1-propanol (0.0045 g, 0.006 mmol) diisopropylethylamine (0.03 g, 0.23 mmol) and HATU (0.022 g, 0.06 mmol) in DMF (2 mL) was stirred at 20 °C under N<sub>2</sub> for 2 days. Solvent was removed and the product was purified by column chromatography (CH<sub>2</sub>Cl<sub>2</sub>/MeOH as solvent) to give 0.019 g of product. The above product was  
15 dissolved in TFA (1.0 mL) and stirred at 20 °C for 2 h before concentration. An ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a yellow solid was formed. The yellow solid was collected through filtration, washed with water and dried under vacuum to give 0.009 g (41%) of **Cmd 39** as a yellow solid; <sup>1</sup>H NMR (300 MHz, CD<sub>3</sub>OD) δ 9.38 (d, J = 2.0 Hz, 1  
20 H), 9.02 (d, J = 2.0 Hz, 1 H), 8.86 (t, J = 2.0 Hz, 1 H), 8.58 (s, 1 H), 8.19 (s, 1 H), 8.06 (t, J = 2.0 Hz, 1 H), 7.59 (dd, J = 8.2, 1.3 Hz, 1 H), 7.31 (t, J = 8.0 Hz, 1 H), 7.02 (dd, J = 7.9, 1.1 Hz, 1 H), 3.68 (t, J = 6.2 Hz, 2 H), 3.55 (m, 2 H), 1.88 (t, J = 6.6 Hz, 2 H); MS (ES) m/z: 384 (M+H<sup>+</sup>).

25

## EXAMPLE 44

## COMPOUND 40

83



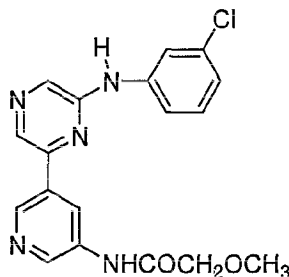
5-[6-[(3-chlorophenyl)amino]pyrazinyl]-*N*-(3-ethoxypropyl)-  
3-pyridinecarboxamide (Cmd 40)

A mixture of **Cmd 3** without the Boc group (0.05 g, 0.15 mmol), 3-ethoxypropylamine (0.016 g, 0.15 mmol), diisopropylethylamine (0.079 g, 0.61 mmol) and HATU (0.058 g, 0.15 mmol) in DMF (3 mL) was stirred at 20 °C under N<sub>2</sub> overnight. Solvent was removed and product was purified by column chromatography (CH<sub>2</sub>Cl<sub>2</sub>/MeOH as solvent) to give 0.057 g (90%) of **Cmd 40** as a yellow solid; <sup>1</sup>H NMR (300 MHz, CD<sub>3</sub>OD) δ 9.36 (s, 1 H), 9.01 (s, 1 H), 8.85 (s, 1 H), 8.57 (s, 1 H), 8.18 (s, 1 H), 8.05 (s, 1 H), 7.58 (dd, J = 8.3, 1.0 Hz, 1 H), 7.30 (t, J = 8.0 Hz, 1 H), 7.00 (dd, J = 8.0, 1.0 Hz, 1 H), 3.71 (m, 1 H), 3.52 (m, 6 H), 3.21 (q, J = 7.4 Hz, 1 H), 1.93 (m, 2 H), 1.18 (t, J = 7.0 Hz, 3 H); MS (ES) m/z: 412 (M+H<sup>+</sup>).

15

## EXAMPLE 45

## COMPOUND 41



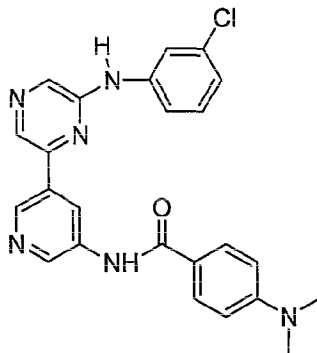
*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-  
3-pyridinyl]-2-methoxyacetamide (Cmd 41)

20 **Cmd 67** (0.052 g, 0.1 mmol) dissolved in anhydrous THF (3 mL) at 0 °C and NaH (60% oil dispersion 0.03 g, 0.7 mmol) was added. After 10 min, methoxyacetylchloride (0.08 g, 0.7 mmol) was added and the reaction was stirred for 2-3 hours at 0 °C under N<sub>2</sub> then allowed to warm up to 20 °C overnight. NH<sub>4</sub>Cl<sub>(aq)</sub> was added to quench the reaction. Solvent was removed

and the product was extracted into  $\text{CH}_2\text{Cl}_2$ , washed with water and dried ( $\text{Na}_2\text{SO}_4$ ). Product was purified by column chromatography (Hex/EtOAc as solvent) to give 0.023 g of a yellow solid. The above product was dissolved in TFA (1.0 mL) and stirred at 20 °C for 1.5 h before concentration. An ammonium  
5 hydroxide solution was added to the residue until the pH was about 10-11 and a yellow solid was formed. The yellow solid was collected through filtration, washed with water and dried under vacuum to give 0.008 g (21%) of **Cmd 41** as a yellow solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CD}_3\text{OD}$ )  $\delta$  8.98 (s, 1 H), 8.86 (brs, 2 H), 8.48 (s, 1 H), 8.15 (s, 1 H), 7.92 (s, 1 H), 7.72 (d,  $J = 8.1$  Hz, 1 H), 7.32 (t,  $J =$   
10 8.0 Hz, 1 H), 6.99 (d,  $J = 7.8$  Hz, 1 H), 4.11 (s, 2 H), 3.52 (s, 3 H); MS (ES)  $m/z$ : 370 ( $\text{M}+\text{H}^+$ ).

## EXAMPLE 46

## COMPOUND 42



15

*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-  
3-pyridinyl]-4-(dimethylamino)-benzamide (**Cmd 42**)

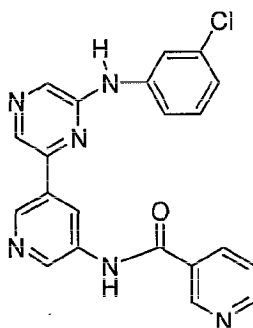
**Cmd 67** (0.05 g, 0.1 mmol) was dissolved in anhydrous THF (3 mL) at 0 °C and NaH (60% oil dispersion 0.04 g, 1.0 mmol) was added. After 10 min, 4-  
20 dimethylaminobenzoylchloride (0.18 g, 1.0 mmol) was added and the reaction was stirred for 2-3 hours at 0 °C under  $\text{N}_2$  then warmed to 20 °C overnight.  $\text{NH}_4\text{Cl}_{(\text{aq})}$  was added to quench the reaction. Solvent was removed and the product was extracted into  $\text{CH}_2\text{Cl}_2$ , washed with water and dried ( $\text{Na}_2\text{SO}_4$ ). Product was purified by column chromatography (Hex/EtOAc as solvent) to  
25 give 0.042 g of product. The above product (0.036 g 0.056 mmol) was dissolved in TFA (1.0 mL) and stirred at 20 °C for 1.5 h before it was concentrated. An ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a tan solid was formed. The tan solid was collected

through filtration, washed with water and dried under vacuum to give 0.0215 g (49%) of **Cmd 42** as a tan solid;  $^1\text{H}$  NMR (300 MHz,  $\text{D}^6\text{-DMSO}$ )  $\delta$  8.97 (m, 3 H), 8.63 (s, 1 H), 8.27 (s, 1 H), 7.96 (m, 3 H), 7.92 (s, 1 H), 7.84 (dd,  $J = 8.2, 1.3$  Hz, 1 H), 7.41 (t,  $J = 8.0$  Hz, 1 H), 7.04 (dd,  $J = 7.9, 1.4$  Hz, 1 H), 6.79 (d,  $J =$   
5 9.0 Hz, 2 H), 3.02 (s, 6 H); MS (ES)  $m/z$  : 445 ( $\text{M}+\text{H}^+$ ). Anal. Calcd. For  $\text{C}_{24}\text{H}_{21}\text{N}_6\text{OCl} \cdot 1.15 \text{H}_2\text{O}$  : C, 61.91; H, 5.04; N, 18.05. Found: C, 62.27; H, 4.83; N, 17.67.

## EXAMPLE 47

## COMPOUND 43

10



*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-

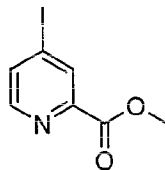
3-pyridinyl]-3-pyridinecarboxamide (**Cmd 43**)

**Cmd 67** (0.05 g, 0.1 mmol) was dissolved in anhydrous THF (3 mL) at 0  
15  $^{\circ}\text{C}$  and NaH (60% oil dispersion 0.04 g, 1.0 mmol) was added. After 10 min, nicotinoyl chloride (0.18 g, 1.0 mmol) was added and the reaction was stirred for 2-3 hours at 0  $^{\circ}\text{C}$  under  $\text{N}_2$  then allowed to warm to 20  $^{\circ}\text{C}$  overnight.  $\text{NH}_4\text{Cl}_{(\text{aq})}$  was added to quench the reaction. Solvent was removed and the product was extracted into  $\text{CH}_2\text{Cl}_2$ , washed with water and dried ( $\text{Na}_2\text{SO}_4$ ). Product was  
20 purified by column chromatography (Hex/EtOAc as solvent) to give 0.02 g of product. The above product was dissolved in TFA (1.0 mL) and stirred at 20  $^{\circ}\text{C}$  for 2 h before it was concentrated. An ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a yellow solid was formed. The yellow solid was collected through filtration, washed with water and dried under  
25 vacuum to give 0.006 g (15%) of **Cmd 43** as a yellow solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CD}_3\text{OD}$ )  $\delta$  9.17 (brs, 1 H), 9.02 (brs, 2 H), 8.94 (brs, 1 H), 8.77 (m, 1 H), 8.52 (s, 1 H), 8.45 (m, 1 H), 8.17 (s, 1 H), 7.94 (brs, 1 H), 7.76 (d,  $J = 8.6$  Hz, 1 H), 7.65 (m, 1 H), 7.34 (t,  $J = 8.2$  Hz, 1 H), 7.05 (m, 1 H); MS (ES)  $m/z$  : 403

(M+H<sup>+</sup>).

## EXAMPLE 48

## Intermediate Compound 3B



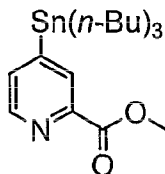
5

A mixture of 4-iodopicolinic acid (hemi-hydroiodide hydrate) (Lohse, Olivier, *Synthetic Communications*, 1996, 26(10), 2017-2025) (10 g, 30.2 mmol), CDI (20 g, 123 mmol) in THF (200 mL) was stirred for 60 h at room temperature. The reaction mixture was cooled in an ice bath. After methanol (200 mL) was added, triethylamine (25.4 g, 251 mmol) was added dropwise. The reaction stirred for 40 h at room temperature. The reaction mixture was concentrated under vacuum. The product was purified by column chromatography (EtOAc/ hexane as solvent) to give 7.3 g (92%) of **3B** as a tan solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.52 (d, J = 1.6 Hz, 1 H), 8.40 (d, J = 5.1 Hz, 1 H), 7.88 (dd, J = 5.1, 1.7 Hz, 1 H), 4.02 (s, 3 H); MS (ES) m/z: 264 (M+H<sup>+</sup>).

15

## EXAMPLE 49

## Intermediate Compound 3C



20

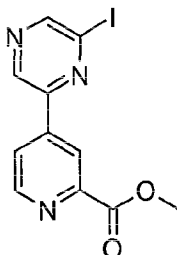
A mixture of **3B** (7.3 g, 27.7 mmol), bis(tributyltin) (19.4 g, 33.4 mmol), palladium acetate (0.28 g, 1.25 mmol), tri-*o*-tolylphosphine (2.2 g, 7.23 mmol) and triethylamine (5.6 g, 55.7 mmol) in acetonitrile (89 mL) was stirred at 80-90 °C for 24 h under nitrogen. The cooled reaction mixture was concentrated under vacuum. The residue was purified by column chromatography (EtOAc/hexane as solvent) to give 8.91 g (75%) of **3C** as a yellow oil; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.61 (m, 1 H), 8.22 (m, 1 H), 7.56 (m, 1 H), 4.01 (s, 3 H), 1.60-0.90 (m, 18 H), 0.89 (t, J = 7.3 Hz, 9 H); MS (ES) m/z: 428 (M+H<sup>+</sup>).

25



## EXAMPLE 50

## Intermediate Compound 3E

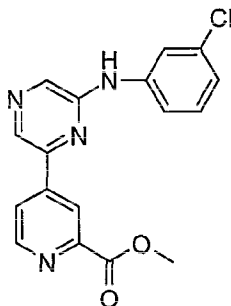


5           A mixture of **3C** (96.7 mg, 0.227 mmol) 2,6-diiodopyrazine (151 mg, 0.454 mmol; Turch, A. et al, *J. Heterocycl. Chem.* **1994**, 31(6), 1449-53),  $\text{Pd}_2(\text{dba})_3$  (6 mg, 0.0057 mmol) and triphenylarsine (14 mg, 0.0454 mmol) in THF (1 mL) was stirred at reflux for 18 h under nitrogen. Aqueous sodium carbonate was added and stirred for 5 min. and then extracted with  
10 dichloromethane. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 16.8 mg (22%) of **3E** as an off-white solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.08 (s, 1 H), 8.92 (m, 2 H), 8.72 (d,  $J = 1.7$  Hz, 1 H), 8.10 (d,  $J = 5.0$  Hz, 1 H), 4.08 (s, 3 H); MS (ES)  $m/z$ : 342 ( $\text{M}+\text{H}^+$ ).

15

## EXAMPLE 51

## COMPOUND 44

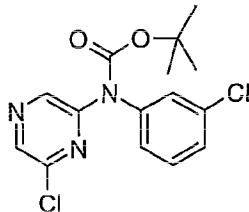


          A mixture of **3E** (416 mg, 1.22 mmol), 3-chloroaniline (234 mg, 1.83 mmol),  $\text{Pd}_2(\text{dba})_3$  (31.6 mg, 0.003 mmol), DPPF (54 mg, 0.096 mmol),  $\text{Cs}_2\text{CO}_3$   
20 (795 mg, 2.44 mmol) in anhydrous dioxane (3.6 mL) was stirred at 100 °C for 24 h under nitrogen. The reaction mixture was concentrated under vacuum. The residue was purified by column chromatography (acetone/dichloromethane as solvent) to give 16 mg (3.8%) of **Cmd 44** as a yellow solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  8.90 (d,  $J = 5.1$  Hz, 1 H), 8.76 (brs, 1 H), 8.65 (s, 1 H), 8.30 (s, 1 H),

8.12 (dd,  $J = 5.1, 1.8$  Hz, 1 H), 7.78 (brs, 1 H), 7.40-7.30 (m, 2 H), 7.12 (d,  $J = 7.5$  Hz, 1 H), 6.73 (s, 1 H), 4.07 (s, 3 H); MS (ES)  $m/z$ : 341 ( $M+H^+$ ).

## EXAMPLE 52

## COMPOUND 45



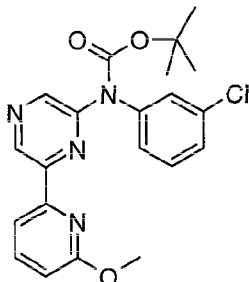
5

A mixture of **Cmd 29** (1.1 g, 4.6 mmol),  $\text{Boc}_2\text{O}$  (3 g, 13.8 mmol) and DMAP (~200mg, cat) in dichloromethane (65 mL) was stirred at 20 °C for 16 h. The reaction mixture was concentrated and the product was purified by column chromatography (EtOAc/hexane as solvent) to give 1.6 g (100%) of **Cmd 45** as a tan wax;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  8.87 (s, 1 H), 8.32 (s, 1 H), 7.34-7.27 (m, 2 H), 7.21 (brs, 1 H), 7.10 (dt,  $J = 6.9, 2.1$  Hz, 1 H), 1.46 (s, 9 H); MS  $m/z$ : 362 ( $M+\text{Na}^+$ ).

10

## EXAMPLE 53

## COMPOUND 46



15

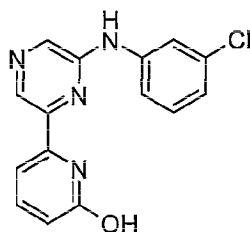
A mixture of 2-methoxy-6-(tributyltin)pyridine (WO9321178, published 28 October 1993 by Pfizer Limited; 384 mg, 1.13 mmol), **Cmd 45** (502 mg, 1.26 mmol),  $\text{Pd}_2(\text{dba})_3$  (27 mg, 0.026 mmol), triphenylarsine (64 mg, 0.21 mmol) and THF (4.5 mL) was refluxed for 4 days under nitrogen. The product was purified by column chromatography (EtOAc/hexane as solvent) and recrystallized from hexane to give 233 mg (45%) of **Cmd 46** as a white solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.36 (s, 1 H), 8.92 (s, 1 H), 7.59 (m, 1 H), 7.50 (dd,  $J = 7.4, 0.8$  Hz, 1 H), 7.37-7.26 (m, 3 H), 7.20 (dt,  $J = 7.3, 1.9$  Hz, 1 H), 6.77 (dd,  $J = 8.1, 0.8$  Hz, 1 H), 4.03 (s, 3 H), 1.49 (s, 9 H); MS (ES)  $m/z$ : 413 ( $M+H^+$ ).

20

25

## EXAMPLE 54

## COMPOUND 47

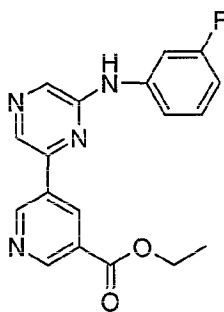


5           A mixture of **Cmd 46** (230 mg, 0.56 mmol) and pyridine hydrochloride (1.6 g, 14 mmol) was heated under nitrogen at 220 °C for 40 min. The cooled reaction mixture was triturated in a mixture of dichloromethane and 30% ammonium hydroxide. Dichloromethane was removed under vacuum and the solid was collected through filtration and dried under vacuum to give 108 mg  
10           (65%) **Cmd 47** as an off-white solid; <sup>1</sup>H NMR (300 MHz, D<sup>6</sup>-DMSO) δ 11.2 (brs, 1 H), 9.92 (brs, 1 H), 8.70 (brs, 1 H), 8.28 (brs, 1 H), 7.99 (brs, 1 H), 7.70-7.50 (m, 2 H), 7.38-7.30 (m, 2 H), 7.06 (brs, 1 H), 6.60 (brs, 1 H); MS (ES) m/z: 298 (M+H<sup>+</sup>).

15

## EXAMPLE 55

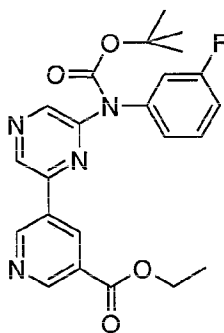
## COMPOUND 48



          A mixture of **1D** (320 mg, 1.22 mmol), 3-fluoroaniline (205 mg, 1.83 mmol), Pd<sub>2</sub>(dba)<sub>3</sub> (31.6 mg, 0.03 mmol), DPPF (54 mg, 0.096 mmol), Cs<sub>2</sub>CO<sub>3</sub>  
20           (795 mg, 2.44 mmol) in anhydrous dioxane (3.6 mL) was stirred at 110 °C for 46 h under nitrogen. Dichloromethane (2 mL) was added to the cooled reaction mixture. The mixture was filtered through celite. The celite cake was washed with more dichloromethane and the combined filtrate was concentrated to give a yellow solid. A small amount of EtOAc was added, and the solid (45 mg) was

collected by filtration. The filtrate was concentrated and purified by column chromatography to give 288 mg of **Cmd 48** as a yellow solid (total yield 80%);  
<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.42 (d, J = 2.2 Hz, 1 H), 9.30 (d, J = 2.0 Hz, 1 H), 8.91 (t, J = 2.1 Hz, 1 H), 8.58 (s, 1 H), 8.26 (s, 1 H), 7.54 (d, J = 10.9 Hz, 1 H), 7.38-7.24 (m, 1 H), 6.91 (s, 1 H), 6.83 (t, J = 8.1 Hz, 1 H), 4.48 (q, J = 7.1 Hz, 2 H), 1.46 (t, J = 7.1 Hz, 3 H); MS (ES) m/z: 339 (M+H<sup>+</sup>).

EXAMPLE 56  
COMPOUND 49

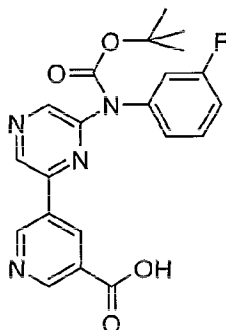


10

A mixture of **Cmd 48** (293 mg, 0.87 mmol), Boc<sub>2</sub>O (378 mg, 1.73 mmol), and DMAP (~40 mg, cat.) in dichloromethane (5.4 mL) was stirred at 20 °C for 18 h. The reaction mixture was concentrated and the product was purified by column chromatography (EtOAc/hexane as solvent) to give 301 mg (79%) of **Cmd 49** as a yellowish oil; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.22 (d, J = 2.0 Hz, 1 H), 9.15 (d, J = 2.2 Hz, 1 H), 9.10 (s, 1 H), 8.84 (s, 1 H), 8.65 (t, J = 2.1 Hz, 1 H), 7.39 (q, J = 6.3 Hz, 1 H), 7.10-7.00 (m, 3 H), 4.43 (q, J = 7.1 Hz, 2 H), 1.49 (s, 9 H), 1.43 (t, J = 7.1 Hz, 3 H); MS (ES) m/z: 439 (M+H<sup>+</sup>). Anal. Calcd. For C<sub>23</sub>H<sub>23</sub>N<sub>4</sub>O<sub>4</sub>F•0.1 H<sub>2</sub>O: C, 62.75; H, 5.31; N, 12.73. Found: C, 62.74; H, 5.19; N, 12.82.

20

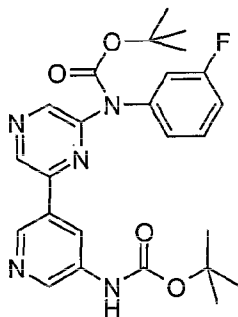
EXAMPLE 57  
COMPOUND 50



A mixture of **Cmd 49** (410 mg, 0.64 mmol) was dissolved in methanol (6.3 mL) and stirred for 10 min then cooled to 0 °C. NaOH<sub>(aq)</sub> (1 N, 1.06 mL) was added slowly and the mixture was stirred at 0 °C for 10 min then stirred at  
 5 20 °C for another 18 h. Glacial acetic acid (0.86 mL) was added to the reaction mixture at 0 °C slowly followed by the addition of water (3.2 mL). A yellow solid was formed. The yellow solid was collected through filtration, washed with water (5x), and dried in a vacuum oven overnight to give 222 mg (85%) of **Cmd 50** as a yellow solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.29 (brs, 1 H), 9.20  
 10 (brs, 1 H), 9.13 (brs, 1 H), 8.86 (brs, 1 H), 8.73 (brs, 1 H), 7.44–7.27 (m, 1 H), 7.07–6.91 (m, 3 H), 1.50 (s, 9 H); MS (ES) m/z: 409 (M-H<sup>+</sup>).

## EXAMPLE 58

## COMPOUND 51



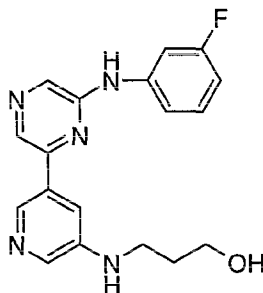
15

A mixture of **Cmd 50** (210 mg, 0.513 mmol), DPPA (169 mg, 0.616 mmol), triethylamine (103 mg, 1.02 mmol), and t-BuOH (2.16 mL) in toluene (1.54 mL) was stirred under nitrogen at 100 °C for 3 h. The reaction mixture was concentrated under vacuum. The product was purified by column  
 20 chromatography (EtOAc/hexane as solvent) to give 77 mg (31%) of **Cmd 51** as a yellowish gum; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.99 (s, 1 H), 8.80 (s, 1 H), 8.68 (d, J = 1.9 Hz, 1 H), 8.46 (d, J = 2.5 Hz, 1 H), 8.38 (brs, 1 H), 7.41–7.27 (m, 1

H), 7.06–7.01 (m, 3 H), 6.58 (brs, 1 H), 1.54 (s, 9 H), 1.49 (s, 9 H); FAB-HRMS ( $M+H^+$ ). Calcd. for  $C_{25}H_{29}N_5O_4F$  482.2204, found 482.2204.

## EXAMPLE 59

## COMPOUND 52



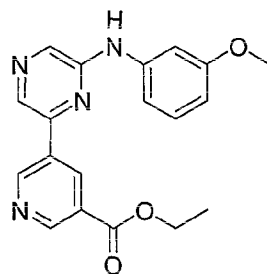
3-[[5-[6-[(3-fluorophenyl)amino]pyrazinyl]-  
3-pyridinyl]amino]-1-propanol (Cmd 52)

A mixture of **Cmd 51** (73 mg 0.152 mmol), (3-bromopropoxy)-*t*-butyl-  
dimethylsilane (57.8 mg, 0.228 mmol) and  $Cs_2CO_3$  (148 mg, 0.456 mmol) in  
DMF (1.9 mL) was stirred at 70 °C under nitrogen for 36 h. The reaction  
mixture was diluted with water, extracted with ether (3x), dried ( $Na_2SO_4$ ) and  
concentrated. The product was purified by column chromatography  
(EtOAc/hexane as solvent) to give 66 mg of the silylated-product as an orange  
oil. The silylated-product was dissolved in TFA (0.7 mL) and stirred at 20 °C for  
1 h before it was concentrated. An ammonium hydroxide solution was added to  
the residue until the pH was about 10-11 and a yellow solid was formed. The  
yellow solid was collected through filtration, washed with water and dried under  
vacuum. The yellow solid was recrystallized from  $CH_3OH/EtOAc$  to give 14 mg  
(27% two steps) of **Cmd 52** as a light yellow solid;  $^1H$  NMR (300 MHz,  
 $CD_3OD$ )  $\delta$  8.46 (s, 1 H), 8.43 (d,  $J = 1.8$  Hz, 1 H), 8.13 (brs, 1 H), 8.01 (d,  $J =$   
2.7 Hz, 1 H), 7.90 (dt,  $J = 12.1, 2.1$  Hz, 1 H), 7.68 (t,  $J = 2.1$  Hz, 1 H), 7.42-7.28  
(m, 2 H), 6.73 (t,  $J = 8.3$  Hz, 1 H), 3.72 (t,  $J = 6.2$  Hz, 2 H), 3.31 (m, 2 H), 1.91  
(m, 2 H); FAB-HRMS ( $M+H^+$ ). Calcd. for  $C_{18}H_{19}N_5OF$  340.1574, found  
340.1586.

## EXAMPLE 60

## COMPOUND 53

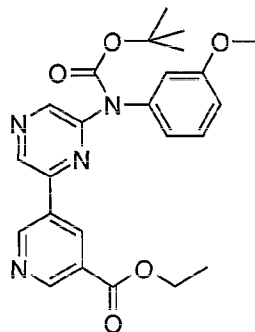
93



A mixture of **1D** (400 mg, 1.53 mmol), 3-methoxyaniline (281 mg, 2.29 mmol),  $\text{Pd}_2(\text{dba})_3$  (39.5 mg, 0.038 mmol), DPPF (67.5 mg, 0.119 mmol),  $\text{Cs}_2\text{CO}_3$  (993 mg, 3.05 mmol) in anhydrous dioxane (4.5 mL) was stirred at 110 °C for 47 h under nitrogen. Dichloromethane (2 mL) was added to the cooled reaction mixture. The mixture was filtered through celite. The celite cake was washed with more dichloromethane and the combined filtrate was concentrated to give a yellow solid. A small amount of EtOAc was added, the solid (226 mg) was collected by filtration and the filtrate was concentrated and purified by column chromatography to give 62 mg of **Cmd 53** as a yellow solid (total yield 65%);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.42 (d,  $J = 2.1$  Hz, 1 H), 9.28 (d,  $J = 2.0$  Hz, 1 H), 8.89 (t,  $J = 2.1$  Hz, 1 H), 8.53 (s, 1 H), 8.27 (s, 1 H), 7.3-7.27 (m, 2 H), 7.05 (dd,  $J = 7.9, 1.3$  Hz, 1 H), 6.78 (brs, 1 H), 6.69 (brd,  $J = 7.6$  Hz, 1 H), 4.48 (q,  $J = 7.1$  Hz, 2 H), 3.85 (s, 3 H), 1.56 (t,  $J = 7.1$  Hz, 3 H); Anal. Calcd for  $\text{C}_{19}\text{H}_{18}\text{N}_4\text{O}_3 \cdot 0.5\text{H}_2\text{O}$ : C, 63.82; H, 5.33; N, 15.59. Found: C, 63.90; H, 5.20; N, 15.35.

## EXAMPLE 61

## COMPOUND 54



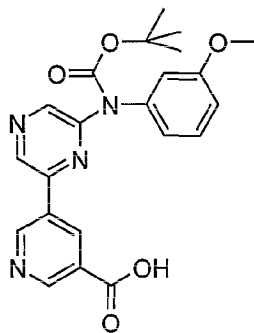
20

A mixture of **Cmd 53** (456 mg, 1.3 mmol),  $\text{Boc}_2\text{O}$  (568 mg, 2.6 mmol), and DMAP (~60 mg, cat.) in dichloromethane (8.7 mL) was stirred at 20 °C for 4 days. The reaction mixture was concentrated and the product was purified by

column chromatography (EtOAc/hexane as solvent) to give 521 mg (89%) of **Cmd 54** as a yellowish oil;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.22 (d,  $J = 1.6$  Hz, 1 H), 9.17 (d,  $J = 1.9$  Hz, 1 H), 9.02 (s, 1 H), 8.81 (s, 1 H), 8.68 (brs, 1 H), 7.33 (t,  $J = 8.1$  Hz, 1 H), 6.90–6.82 (m, 3 H), 4.44 (q,  $J = 7.1$  Hz, 2 H), 3.81 (s, 3 H), 1.49 (s, 9 H), 1.43 (t,  $J = 7.1$  Hz, 3 H); MS (ES)  $m/z$ : 451 ( $\text{M}+\text{H}^+$ ). Anal. Calcd. For  $\text{C}_{24}\text{H}_{26}\text{N}_4\text{O}_5$ : C, 63.99; H, 5.82; N, 12.44. Found: C, 63.85; H, 5.40; N, 12.14 (error = 0.42%); FAB-HRMS ( $\text{M}+\text{H}^+$ ). Calcd. for  $\text{C}_{24}\text{H}_{27}\text{N}_4\text{O}_5$  451.1981, found 451.2007.

10

EXAMPLE 62  
COMPOUND 55

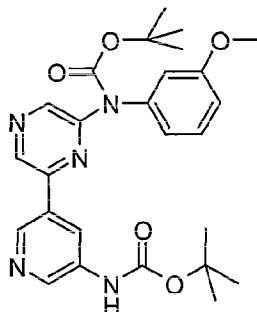


A mixture of **Cmd 54** (521 mg, 1.16 mmol) was dissolved in methanol (11.4 mL) and stirred for 10 min then cooled to 0 °C.  $\text{NaOH}_{(\text{aq})}$  (1 N, 1.92 mL) was added slowly and the mixture was stirred at 0 °C for 10 min then stirred at 20 °C for another 18 h. Glacial acetic acid (1.6 mL) was added to the reaction mixture at 0 °C slowly followed by the addition of water (6 mL). A yellow solid was formed. The yellow solid was collected through filtration, washed with water (5x), and dried in a vacuum oven overnight to give 399 mg (80%) of **Cmd 55** as a yellow solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CD}_3\text{OD}$ )  $\delta$  9.16 (d,  $J = 2.2$  Hz, 1 H), 9.11 (d,  $J = 1.9$  Hz, 1 H), 9.04 (s, 1 H), 8.98 (s, 1 H), 8.82 (t,  $J = 2.1$  Hz, 1 H), 7.35 (t,  $J = 8.0$  Hz, 1 H), 6.96–6.85 (m, 3 H), 3.81 (s, 3 H), 1.48 (s, 9 H); MS (ES)  $m/z$ : 421 ( $\text{M}-\text{H}^+$ ). Anal. Calcd. For  $\text{C}_{22}\text{H}_{22}\text{N}_4\text{O}_5 \cdot 0.3 \text{H}_2\text{O}$ : C, 61.76; H, 5.32; N, 13.10. Found: C, 61.88; H, 5.21; N, 12.98.

25

EXAMPLE 63  
COMPOUND 56





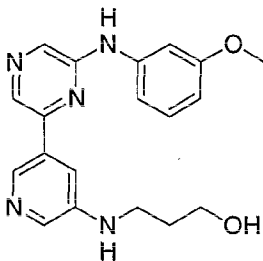
A mixture of **Cmd 55** (392 mg, 0.928 mmol), DPPA (307 mg, 1.12 mmol), triethylamine (188 mg, 1.86 mmol), and t-BuOH (3.9 mL) in toluene (2.8 mL) was stirred under nitrogen at 70 °C for 30 min. and then 100 °C for 3 h.

5 The reaction mixture was concentrated under vacuum. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 343 mg (75%) of **Cmd 56** as a yellowish gum; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.91 (s, 1 H), 8.78 (s, 1 H), 8.71 (d, J = 1.9 Hz, 1 H), 8.49 (d, J = 2.5 Hz, 1 H), 8.38 (brs, 1 H), 7.31 (t, J = 8.2 Hz, 1 H), 6.87-6.82 (m, 3 H), 6.63 (brs, 1 H), 3.81 (s, 3 H), 1.54 (s, 9

10 H), 1.49 (s, 9 H); MS (ES) m/z: 494 (M+H<sup>+</sup>).

## EXAMPLE 64

## COMPOUND 57



15 3-[[5-[6-[(3-methoxyphenyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-propanol (**Cmd 57**)

A mixture of **Cmd 56** (343 mg, 0.70 mmol), (3-bromopropoxy)-*t*-butyldimethylsilane (354 mg, 1.4 mmol) and Cs<sub>2</sub>CO<sub>3</sub> (684 mg, 2.1 mmol) in DMF (8.8 mL) was stirred at 70 °C under nitrogen for 18 h. The reaction mixture was

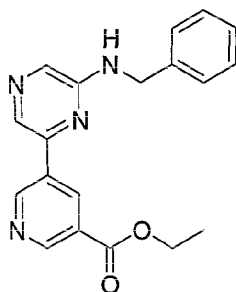
20 diluted with water, extracted with ether (3x), dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 246 mg of the silylated-product as an orange oil.

The silylated-product was dissolved in TFA (2.6 mL) and stirred at 20 °C for 18

h before it was concentrated. An ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a yellow solid was formed. The yellow solid was collected through filtration, washed with water and dried under vacuum. The yellow solid was recrystallized from CH<sub>3</sub>OH/EtOAc to give 24.3 mg (9.9% two steps) of **Cmd 57** as a light yellow solid; <sup>1</sup>H NMR (300 MHz, CD<sub>3</sub>OD) δ 8.44 (d, J = 1.6 Hz, 1 H), 8.39 (s, 1 H), 8.10 (s, 1 H), 8.00 (d, J = 2.8 Hz, 1 H), 7.67 (brs, 1 H), 7.65 (brs, 1 H), 7.23-7.20 (m, 2 H), 6.62-6.58 (m, 1 H), 3.81 (s, 3 H), 3.72 (t, J = 6.2 Hz, 2 H) 3.31 (m, 2 H), 1.90 (m, 2 H); Anal. Calcd. For C<sub>19</sub>H<sub>21</sub>N<sub>5</sub>O<sub>2</sub>•0.5 H<sub>2</sub>O: C, 63.32; H, 6.15; N, 19.43. Found: C, 63.51; H, 5.93; N, 19.31.

## EXAMPLE 65

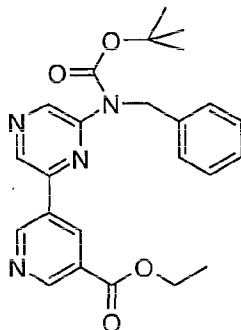
## COMPOUND 58



A mixture of **1D** (320 mg, 1.22 mmol), benzylamine (144 mg, 1.34 mmol), Pd<sub>2</sub>(dba)<sub>3</sub> (32 mg 0.03 mmol), DPPF (54 mg, 0.096 mmol), and Cs<sub>2</sub>CO<sub>3</sub> (795 mg, 2.44 mmol) in anhydrous dioxane (3.6 mL) was stirred at 110 °C for 39 h under nitrogen. The cooled reaction mixture was concentrated and purified by column chromatography to give 130 mg of **Cmd 58** as a green oil (total yield 28%); <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.35 (d, J = 2.2 Hz, 1 H), 9.25 (d, J = 2.0 Hz, 1 H), 8.84 (t, J = 2.0 Hz, 1 H), 8.37 (s, 1 H), 7.94 (s, 1 H), 7.43 – 7.38 (m, 5 H), 5.13 (m, 1 H), 4.68 (d, J = 5.7 Hz, 2 H), 4.46 (q, J = 7.2 Hz, 2 H), 1.45 (t, J = 7.2 Hz, 3 H); FAB-HRMS (M+H<sup>+</sup>). Calcd. for C<sub>19</sub>H<sub>19</sub>N<sub>4</sub>O<sub>2</sub> 335.1508, found 335.1515.

## EXAMPLE 66

## COMPOUND 59



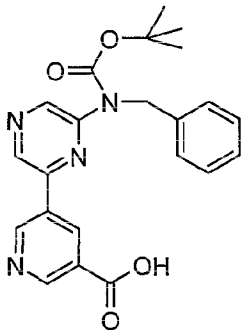
A mixture of **Cmd 58** (220 mg, 1.658 mmol),  $\text{Boc}_2\text{O}$  (431 mg, 1.98 mmol), and DMAP (~30 mg, cat.) in dichloromethane (4.1 mL) was stirred at 20 °C for 4 days. The reaction mixture was concentrated and the product was

5 purified by column chromatography (EtOAc/hexane as solvent) to give 195 mg (68%) of **Cmd 59** as a white solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.27 (dd,  $J$  = 7.9, 2.2 Hz, 2 H), 9.22 (s, 1 H), 8.78 (t,  $J$  = 2.1 Hz, 1 H), 8.74 (s, 1 H), 7.35-7.21 (m, 5 H), 5.30 (s, 2 H), 4.46 (q,  $J$  = 7.1 Hz, 2 H), 1.50 (s, 9 H), 1.43 (t,  $J$  = 7.1 Hz, 3 H); FAB-HRMS ( $\text{M}+\text{H}^+$ ). Calcd. for  $\text{C}_{24}\text{H}_{27}\text{N}_4\text{O}_4$  435.2032, found

10 435.2058.

## EXAMPLE 67

## COMPOUND 60



15 A mixture of **Cmd 59** (195 mg, 0.449 mmol) was dissolved in methanol (4.4 mL) and stirred for 10 min then cooled to 0 °C.  $\text{NaOH}_{(\text{aq})}$  (1 N, 0.94 mL) was added slowly and the mixture was stirred at 0 °C for 10 min then stirred at 20 °C for another 18 h. Glacial acetic acid (0.8 mL) was added to the reaction mixture at 0 °C slowly followed by the addition of water (3 mL). A solid was

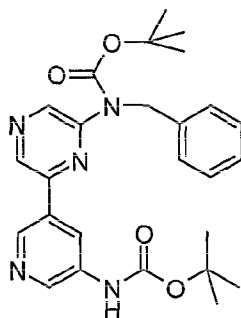
20 formed and was collected by filtration, washed with water (5x), and dried in vacuum oven overnight to give 399 mg (80%) of **Cmd 60** as a white solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CD}_3\text{OD}$ )  $\delta$  9.29 (d,  $J$  = 2.0 Hz, 1 H), 9.17 (s, 1 H), 9.15 (d,  $J$  =

1.6 Hz, 1 H), 8.94 (t,  $J = 2.1$  Hz, 1 H), 8.90 (s, 1 H), 7.42–7.19 (m, 5 H), 5.30 (s, 2 H), 1.50 (s, 9 H); MS (ES)  $m/z$ : 405 ( $M-H^+$ ); Anal. Calcd. For  $C_{22}H_{22}N_4O_4 \cdot 0.4 H_2O$ : C, 63.88; H, 5.56; N, 13.54. Found: C, 63.85; H, 5.44; N, 13.30.

5

## EXAMPLE 68

## COMPOUND 61

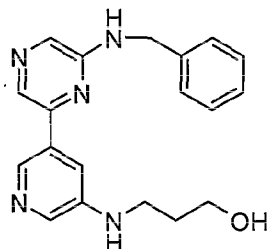


A mixture of **Cmd 60** (128 mg, 0.315 mmol), DPPA (104 mg, 0.38 mmol), triethylamine (64 mg, 0.68 mmol), and *t*-BuOH (1.33 mL) in toluene (0.95 mL) was stirred under nitrogen at 70 °C for 30 min. and then at 100 °C for 19 h. The reaction mixture was concentrated under vacuum. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 89 mg (59%) of **Cmd 61** as a white solid;  $^1H$  NMR (300 MHz,  $CDCl_3$ )  $\delta$  9.13 (s, 1 H), 8.81 (d,  $J = 1.8$  Hz, 1 H), 8.69 (s, 1 H), 8.55 (d,  $J = 2.4$  Hz, 1 H), 8.38 (brs, 1 H), 7.35–7.21 (m, 5 H), 6.56 (brs, 1 H), 5.28 (s, 2 H), 1.55 (s, 9 H), 1.50 (s, 9 H); MS (ES)  $m/z$  478 ( $M+H^+$ ).

20

## EXAMPLE 69

## COMPOUND 62



3-[[5-[6-[(phenylmethyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-propanol (**Cmd 62**)

A mixture of **Cmd 61** (83 mg, 0.174 mmol), (3-bromopropoxy)-*t*-butyldimethylsilane (66 mg, 0.26 mmol) and  $Cs_2CO_3$  (170 mg, 0.522 mmol) in DMF

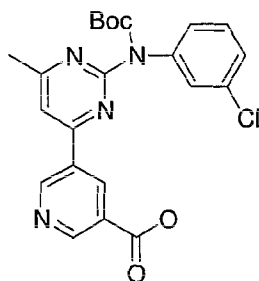
(2.1 mL) was stirred at 70 °C under nitrogen for 3 days. The reaction mixture was diluted with water, extracted with dichloromethane (3x), dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 54 mg of the silylated-product as orange oil.

- 5 The silylated-product was dissolved in TFA (0.6 mL) and stirred at 20 °C for 4 h before it was concentrated. An ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a greenish solid was formed. The greenish solid was collected by filtration, washed with water, and dried under vacuum. The greenish solid was recrystallized from CH<sub>3</sub>OH/EtOAc to give 10  
10 mg (17% two steps) of **Cmd 62** as a light greenish solid; <sup>1</sup>H NMR (300 MHz, CD<sub>3</sub>OD) δ 8.30 (s, 1 H), 8.15 (s, 1 H), 7.93 (brs, 1 H), 7.86 (s, 1 H), 7.54 (s, 1 H), 7.42 -7.20 (m, 5 H), 4.64 (s, 2 H), 3.70 (t, J = 6.1 Hz, 2 H), 3.24 (t, J = 6.6 Hz, 2 H), 1.86 (m, 2 H); MS (ES) m/z: 336 (M+H<sup>+</sup>).

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## EXAMPLE 70

## COMPOUND 63

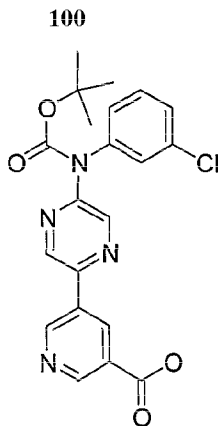


- Refer to Example 12 for preparation of **Cmd 63**, an intermediate for  
20 **Cmd 9**. Characterized as a light-brown solid; MS (ES) m/z: 439 (M-H<sup>+</sup>). Anal. Calcd. For C<sub>22</sub>H<sub>21</sub>N<sub>4</sub>O<sub>4</sub>Cl•0.5 H<sub>2</sub>O: C, 58.73; H, 4.93; N, 12.45. Found: C, 59.04; H, 4.88; N, 12.23

25

## EXAMPLE 71

## COMPOUND 64

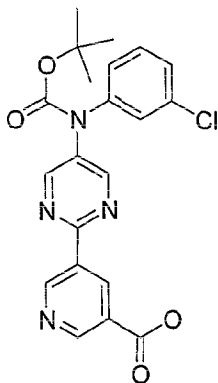


Refer to Example 17 for the preparation of **Cmd 64**, an intermediate for **Cmd 14**. Characterized as an off-white solid; MS (ES)  $m/z$ : 425 ( $M-H^+$ ).

5

## EXAMPLE 72

## COMPOUND 65

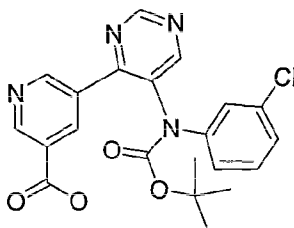


Refer to Example 22 for the preparation of **Cmd 65**, an intermediate for **Cmd 19**. Characterized as a yellow solid; MS (ES)  $m/z$ : 425 ( $M-H^+$ ).

10

## EXAMPLE 73

## COMPOUND 66



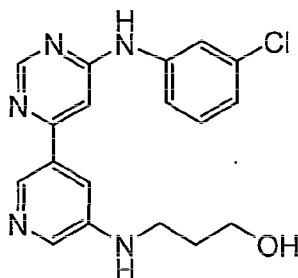
Refer to Example 27 for the preparation of **Cmd 66**, an intermediate for **Cmd 24**. Characterized as a yellow solid;  $^1H$  NMR (300 MHz,  $CDCl_3$ )  $\delta$  9.35 (d,  $J = 1.7$  Hz, 1 H), 9.28 (s, 1 H), 9.18 (d,  $J = 2.1$  Hz, 1 H), 8.78 (s, 1 H), 8.72 (t,

15

$J = 2.0$  Hz, 1 H), 7.11(m, 3 H), 6.90 (brd,  $J = 7.4$  Hz, 1 H), 1.35 (s, 9 H); MS (ES)  $m/z$ : 425 ( $M-H^+$ ).

## EXAMPLE 74

## COMPOUND 68



3-[[5-[6-[(3-chlorophenyl)amino]-4-pyrimidinyl]-3-pyridinyl]amino]-1-propanol (Cmd 68)

A mixture of 4,6-dichloropyrimidine Compound 74a (4 g, 26.9 mmol), 3-chloroaniline (3.44 g, 26.9 mmol), palladium acetate (121 mg, 38 mmol), BINAP (368 mg, 59 mmol) and NaO-*t*-Bu (3.61 g, 217 mmol) in toluene (100 mL) was stirred at 90 °C for 40 h under nitrogen. The cooled reaction mixture was concentrated under vacuum. The residue was diluted with dichloromethane, filtered thru celite, the celite washed with acetone and the combined filtrates were concentrated under vacuum. The product was purified by column chromatography (100% dichloromethane as solvent) to give 250 mg (4%) of Compound 74b as a solid;  $^1\text{H}$  NMR (300 MHz,  $D^6$ -DMSO)  $\delta$  8.56 (s, 1 H), 7.94 (s, 1 H), 7.44 (d,  $J = 8.4$  Hz, 1 H), 7.38 (t,  $J = 8.0$  Hz, 1 H), 7.12 (d,  $J = 8.2$  Hz, 1 H), 6.84 (s, 1 H); MS (ES)  $m/z$ : 240 ( $M+H^+$ ). A mixture of Compound 74b (240 mg, 1 mmol),  $\text{Boc}_2\text{O}$  (436 mg, 2 mmol), DMAP (cat.) in  $\text{CH}_2\text{Cl}_2$  was stirred at 20 °C for 3 h and concentrated. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 308 mg (91%) of Compound 74c as an oil; MS (ES)  $m/z$ : 362 ( $M+\text{Na}$ ). Anal. Calcd. For  $\text{C}_{15}\text{H}_{15}\text{N}_3\text{O}_2\text{Cl}_2$ : C, 52.96; H, 4.44; N, 12.35. Found: C, 52.91; H, 4.43; N, 12.23.

A mixture of 5-bromonicotinic acid Compound 74d (7.14 g, 35.4 mmol), *t*-BuOH (155 mL), triethylamine (6.08 g, 60 mmol), DPPA (10.69 g, 38.9 mmol) in toluene (115 mL) was stirred at 65 °C for 30 min then warmed up to 95 °C for 15 h under nitrogen. The cooled reaction mixture was concentrated under

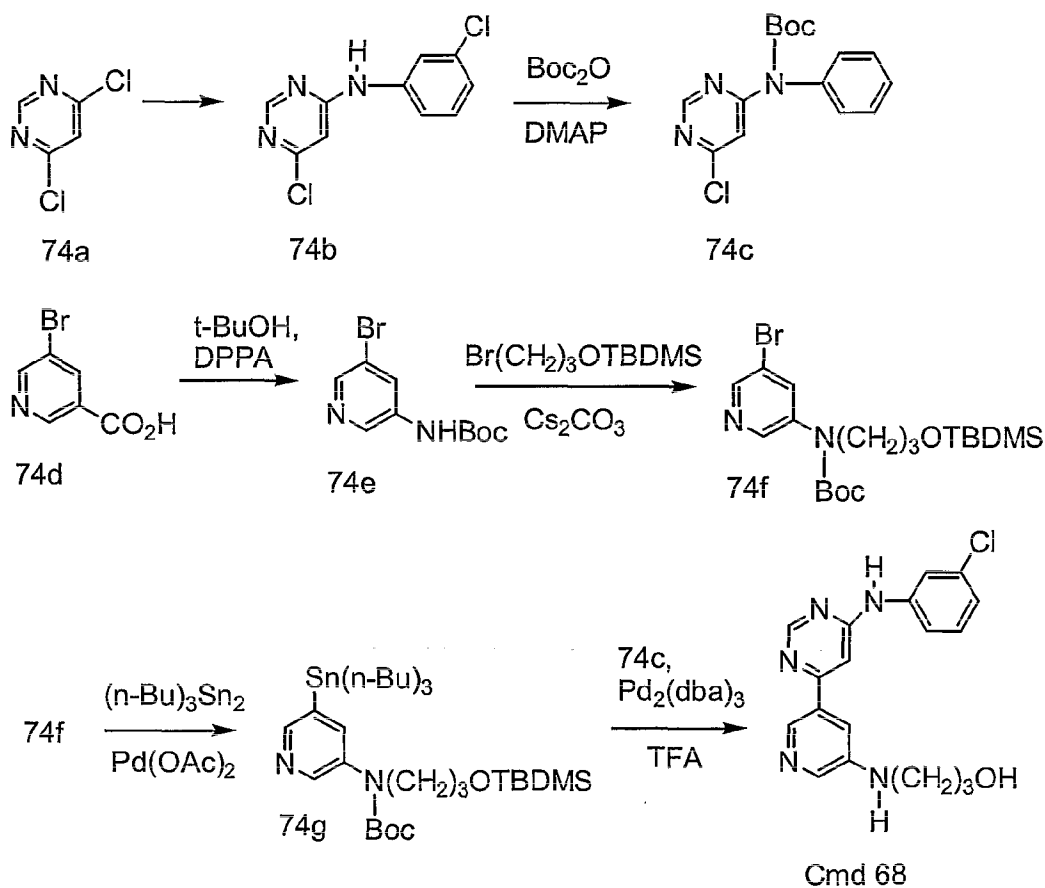
vacuum. The product was purified by column chromatography (SiO<sub>2</sub>, ethylacetate/hexane as solvent) to give 2.9 g (30%) of Compound **74e** as a white solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.32 (m, 3 H), 6.97 (brs, 1 H), 1.53 (s, 9 H); MS (ES) m/z: 273, 275 (M+H<sup>+</sup>). Anal. Calcd. For C<sub>10</sub>H<sub>13</sub>N<sub>2</sub>O<sub>2</sub>Br: C, 43.98; H, 4.80; N, 10.26. Found: C, 43.88; H, 4.52; N, 10.20. A mixture of Compound **74e** (2.85 g, 10.44 mmol), (3-bromopropoxy)-t-butyldimethylsilane (3.96 g, 15.66 mmol) and Cs<sub>2</sub>CO<sub>3</sub> (10.21 g, 31.3 mmol), in anhydrous DMF (55 mL) was stirred at 70 °C for 23 h under nitrogen. The cooled reaction mixture was diluted with water and extracted with ether (3x), dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 4.2 g (90%) of Compound **74f** as yellow oil; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.45 (brs, 2 H), 7.77 (brs, 1 H), 3.73 (brt, *J* = 7.3 Hz, 2 H), 3.62 (t, *J* = 5.9 Hz, 2 H), 1.81 (m, 2 H), 1.45 (s, 9 H), 0.84 (s, 9 H), 0.00 (s, 6 H); MS (ES) m/z: 445, 447 (M+H<sup>+</sup>). Anal. Calcd. For C<sub>19</sub>H<sub>33</sub>N<sub>2</sub>O<sub>3</sub>BrSi: C, 51.23; H, 7.47; N, 6.29. Found: C, 51.45; H, 7.47; N, 6.53.

A mixture of Compound **74f** (500 mg, 1.12 mmol), bis(tributyltin) (780 mg, 1.345 mmol), tri-*o*-tolylphosphine (88.5 mg, 0.29 mmol), palladium acetate (11.3 mg, 0.05 mmol), triethylamine (226 mg, 2.24 mmol) in acetonitrile was stirred at 95-100 °C for 23 h under nitrogen. The cooled reaction mixture was concentrated, sodium carbonate solution was added and stirred for 10 min before extracted with hexane (4x). The combined hexane was filtered thru celite, dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 395 mg (54%) of Compound **74g** as an oil; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.39 (d, *J* = 1.2 Hz, 1 H), 8.37 (m, 1 H), 7.55 (m, 1 H), 3.72 (brt, *J* = 7.3 Hz, 2 H), 3.63 (t, *J* = 6.2 Hz, 2 H), 1.89-1.10 (m, 29 H), 0.89 (t, *J* = 7.2 Hz, 9 H), 0.85 (s, 9 H), 0.00 (s, 6 H); MS (ES) m/z: 657 (M+H<sup>+</sup>). A mixture of Compound **74g** (396 mg, 0.6 mmol), Compound **74c** (293 mg, 0.86 mmol), Pd<sub>2</sub>(dba)<sub>3</sub> (16 mg, 0.015 mmol), triphenylarsine (37 mg, 0.12 mmol) in THF (8 mL) was refluxed for 41 h under nitrogen. The reaction mixture was concentrated, sodium carbonate solution was added and stirred for 10 min before extracted with ether (3x). The combined ether layer was dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 63 mg (16%) of the



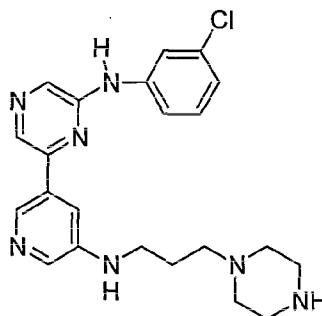
silylated-product as oil; MS (ES)  $m/z$ : 670 ( $M+H^+$ ).

The silylated-product was dissolved in TFA (2 mL) and stirred at room temperature for 5 h before it was concentrated. An ammonium hydroxide solution was added to the solution until the pH was about 10-11, water was added and a yellow solid was formed. The yellow solid was collected thru filtration, washed with more water, dried under vacuum. The yellow solid was purified by column chromatography (dry loading, methylene chloride/methanol as solvent) to give 26 mg (77%) of **Cmd 68** as yellow solid;  $^1H$  NMR (300 MHz,  $D^6$ -DMSO)  $\delta$  9.94 (s, 1 H), 8.79 (s, 1 H), 8.36 (s, 1 H), 8.08 (brs, 2 H), 7.56 (d,  $J=9.2$  Hz, 1 H), 7.47 (s, 1 H), 7.37 (t,  $J=8.1$  Hz, 1 H), 7.24 (s, 1 H), 7.07 (d,  $J=7.8$  Hz, 1 H), 6.14 (m, 1 H), 4.55 (t,  $J=5$  Hz, 1 H), 3.53 (m, 2 H), 3.17 (m, 2 H), 1.75 (m, 2 H); MS (ES)  $m/z$ : 356 ( $M+H^+$ ). Anal. Calcd. For  $C_{18}H_{18}N_5OCl \cdot 0.2 H_2O$ : C, 60.15; H, 5.16; N, 19.48. Found: C, 60.31; H, 5.10; N, 19.15.



## EXAMPLE 75

## COMPOUND 69



5 *N*-(3-chlorophenyl)-6-[5-[[3-(1-piperazinyl)propyl]amino]-  
3-pyridinyl]-2-pyrazinamine (Cmd 69)

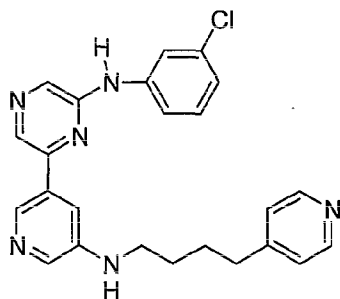
A mixture of **Cmd 67** (prepared as described in Example 6) (0.1 g, 0.2 mmol), Boc protected 1-(3-chloropropyl)piperazine, (0.079 g, 0.3 mmol) and  $\text{Cs}_2\text{CO}_3$  (0.197 g, 0.6 mmol) in DMF (4 mL) was stirred at 70 °C under nitrogen  
10 for 20 h. The reaction mixture was diluted with water, extracted with ether (3x), dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. The product was purified by column chromatography ( $\text{CH}_2\text{Cl}_2/\text{MeOH}$  as solvent) to give 0.192 g of product as an oil. The oil was dissolved in TFA (2.0 mL) and stirred at 20 °C for 2 h before concentrated. Ammonium hydroxide solution was added to the residue until the  
15 pH was about 10-11 and a yellow solid was formed. The yellow solid was collected through filtration, washed with water and dried under vacuum to give 0.072 g (65 %) of **Cmd 69** as a yellow solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CD}_3\text{OD}$ )  $\delta$  8.43 (m, 2 H), 8.18 (d,  $J = 2.0$  Hz, 1 H), 8.11 (s, 1 H), 8.00 (d,  $J = 2.5$  Hz, 1 H), 7.65 (s, 1 H), 7.49 (brd,  $J = 8.0$  Hz, 1 H), 7.29 (t,  $J = 8.0$  Hz, 1 H), 6.99 (d,  $J =$   
20 7.0 Hz, 1 H), 3.30 (m, 2 H), 2.86 (m, 4 H), 2.51 (m, 6 H), 1.88 (m, 2 H); MS (ES)  $m/z$ : 424 ( $\text{M} + \text{H}^+$ ). Anal. Calcd. For  $\text{C}_{22}\text{H}_{26}\text{N}_7\text{Cl} \cdot 0.9 \text{H}_2\text{O}$ : C, 60.03; H, 6.37; N, 22.28. Found: C, 60.24; H, 6.14; N, 21.94.

## EXAMPLE 76

## COMPOUND 70

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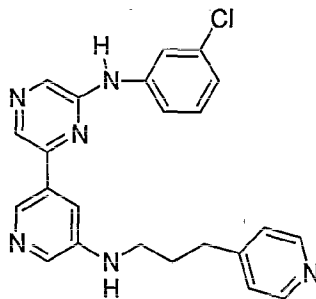


*N*-(3-chlorophenyl)-6-[5-[[4-(4-pyridinyl)butyl]amino]-  
3-pyridinyl]-2-pyrazinamine (Cmd 70)

A mixture of **Cmd 67** (prepared as described in Example 6) (0.1 g, 0.2  
5 mmol), 4-(4-pyridinyl)butyl chloride (0.05 g, 0.3 mmol, Cheng, Tetrahedron  
**1993**, 49, 5767-5776) and  $\text{Cs}_2\text{CO}_3$  (0.197 g, 0.6 mmol) in DMF (4 mL) was  
stirred at 70 °C under nitrogen for 20 h. The reaction mixture was diluted with  
water, extracted with ether (3x), dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. The product  
was purified by column chromatography ( $\text{CH}_2\text{Cl}_2/\text{MeOH}$  as solvent) to give 0.12  
10 g of product as an oil. The oil was dissolved in TFA (2.0 mL) and stirred at 20  
°C for 2 h before concentrated. Ammonium hydroxide solution was added to the  
residue until the pH was about 10-11. The aqueous layer was extracted with  
 $\text{CH}_2\text{Cl}_2$ , dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. Product was purified by column  
chromatography ( $\text{CH}_2\text{Cl}_2/\text{MeOH}$  as solvent) to give 0.06 g (74%) of **Cmd 70** as  
15 a light yellow solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  8.52 (m, 4 H), 8.17 (s, 1 H),  
8.09 (d,  $J = 2.3$  Hz, 1 H), 7.92 (s, 1 H), 7.50 (s, 1 H), 7.28 (s, 1 H), 7.12 (d,  $J =$   
5.4 Hz, 2 H), 7.06 (m, 1 H), 6.83 (s, 1 H), 3.81 (brs, 1 H), 3.26 (q,  $J = 5.9$  Hz, 2  
H), 2.69 (t,  $J = 7.0$  Hz, 2 H), 1.77 (m, 4 H); MS (ES)  $m/z$ : 431 ( $\text{M} + \text{H}^+$ ). Anal.  
Calcd. For  $\text{C}_{24}\text{H}_{23}\text{N}_6\text{Cl} \cdot 0.3 \text{ H}_2\text{O}$ : C, 66.06; H, 5.45; N, 19.26. Found: C, 66.10;  
20 H, 5.40; N, 19.11.

## EXAMPLE 77

## COMPOUND 71

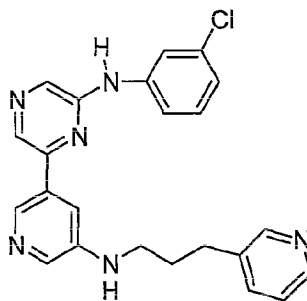


*N*-(3-chlorophenyl)-6-[5-[[3-(4-pyridinyl)propyl]amino]-  
3-pyridinyl]-2-pyrazinamine (Cmd 71)

A mixture of **Cmd 67** (prepared as described in Example 6) (0.1 g, 0.2 mmol), 4-(3-chloropropyl)pyridine (0.047 g, 0.3 mmol, Eisch, John JOC 1974, 39(21) 3110-4) and Cs<sub>2</sub>CO<sub>3</sub> (0.197 g, 0.6 mmol) in DMF (4 mL) was stirred at 70 °C under nitrogen for 20 h. The reaction mixture was diluted with water, extracted with ether (3x), dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. The product was purified by column chromatography (EtOAc/MeOH as solvent) to give 0.074 g of product as an oil. The oil was dissolved in TFA (2.0 mL) and stirred at 20 °C for 2 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11. The aqueous layer was extracted with CH<sub>2</sub>Cl<sub>2</sub>, dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. Product was purified by column chromatography (CH<sub>2</sub>Cl<sub>2</sub>/MeOH as solvent) to give 0.045 g (91%) of **Cmd 71** as a yellow solid; <sup>1</sup>H NMR (300 MHz, CD<sub>3</sub>OD) δ 8.42 (m, 4 H), 8.12 (s, 2 H), 7.99 (s, 1 H), 7.65 (s, 1 H), 7.48 (m, 1 H), 7.34 (s, 2 H), 7.25 (t, *J* = 8.0 Hz, 1 H), 6.97 (d, *J* = 6.7 Hz, 1 H), 3.30 (m, 2 H), 2.83 (m, 2 H), 2.03 (m, 2 H); MS (ES) *m/z*: 417 (M+H<sup>+</sup>).

EXAMPLE 78

COMPOUND 72



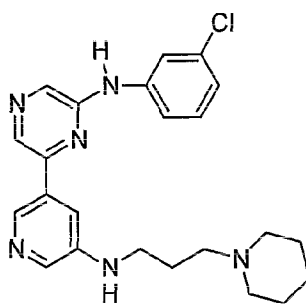
*N*-(3-chlorophenyl)-6-[5-[[3-(3-pyridinyl)propyl]amino]-  
3-pyridinyl]-2-pyrazinamine (Cmd 72)

A mixture of **Cmd 67** (prepared as described in Example 6) (0.1 g, 0.2 mmol), 3-(3-chloropropyl)pyridine (0.047 g, 0.3 mmol, Eisch, John, JOC 1974, 39(21), 3110-3114) and Cs<sub>2</sub>CO<sub>3</sub> (0.197 g, 0.6 mmol) in DMF (4 mL) was stirred at 70 °C under nitrogen for 20 h. The reaction mixture was diluted with water, extracted with ether (3x), dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. The product was purified by column chromatography (CH<sub>2</sub>Cl<sub>2</sub>/MeOH as solvent) to give 0.093 g

of product as an oil. The oil was dissolved in TFA (2.0 mL) and stirred at 20 °C for 2 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11. The aqueous layer was extracted with CH<sub>2</sub>Cl<sub>2</sub>, dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. Product was purified by column chromatography (CH<sub>2</sub>Cl<sub>2</sub>/MeOH as solvent) to give 0.049 g (78%) of **Cmd 72** as a yellow solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.55 (m, 4 H), 8.24 (s, 1 H), 8.07 (s, 1 H), 7.81 (m, 2 H), 7.54 (m, 2 H), 7.27 (m, 2 H), 7.06 (d, *J* = 7.1 Hz, 1 H), 3.95 (m, 1 H), 3.28 (m, 2 H), 2.80 (t, *J* = 7.3 Hz, 2 H), 2.05 (m, 2 H); MS (ES) *m/z*: 417 (M+H<sup>+</sup>). Anal. Calcd. For C<sub>23</sub>H<sub>21</sub>N<sub>6</sub>Cl • 0.7 H<sub>2</sub>O : C, 64.32; H, 5.26; N, 19.57. Found: C, 64.46; H, 4.97; N, 19.25.

## EXAMPLE 79

## COMPOUND 73



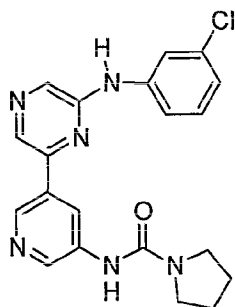
A mixture of **Cmd 67** (prepared as described in Example 6) (0.15 g, 0.3 mmol), 1-(3-chloropropyl)piperidine (0.073 g, 0.45 mmol, US 5414010) and Cs<sub>2</sub>CO<sub>3</sub> (0.3 g, 0.9 mmol) in DMF (6 mL) was stirred at 70 °C under nitrogen for 20 h. The reaction mixture was diluted with water, extracted with ether (3x), dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. The product was purified by column chromatography (CH<sub>2</sub>Cl<sub>2</sub>/MeOH as solvent) to give 0.12 g of product as an oil. The oil was dissolved in TFA (3.0 mL) and stirred at 20 °C for 2 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11. The aqueous layer was extracted with CH<sub>2</sub>Cl<sub>2</sub>, dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. Product was purified by column chromatography (CH<sub>2</sub>Cl<sub>2</sub>/MeOH as solvent) to give 0.067 g (83%) of **Cmd 73** as a light yellow solid; <sup>1</sup>H NMR (300 MHz, CD<sub>3</sub>OD) δ 8.46 (s, 1 H), 8.42 (s, 1 H), 8.16 (s, 1 H), 8.11 (s, 1 H), 8.00 (s, 1 H), 7.65 (s, 1 H), 7.49 (d, *J* = 9.0 Hz, 1 H), 7.29 (t, *J* = 8.0 Hz, 1 H), 6.99 (d, *J* = 8.0 Hz, 1 H), 3.28 (m, 2 H), 2.57 (m, 6 H), 1.90 (m, 2

H), 1.63 (m, 4 H), 1.49 (d,  $J = 4.4$  Hz, 2 H); MS (ES)  $m/z$ : 423 ( $M+H^+$ ). Anal. Calcd. For  $C_{23}H_{27}N_6Cl \cdot 0.7 H_2O$ : C, 63.42; H, 6.57; N, 19.29. Found: C, 63.21; H, 6.28; N, 18.97.

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## EXAMPLE 80

## COMPOUND 74



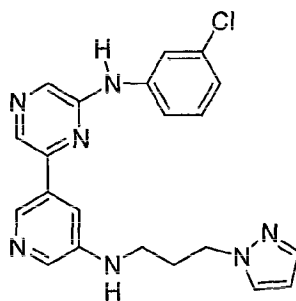
*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-  
3-pyridinyl]-1-pyrrolidinecarboxamide (Cmd 74)

10 A mixture of **Cmd 67** (prepared as described in Example 6) (0.15 g, 0.3 mmol), *N*-(4-bromobutyl)pyrrolidinium bromide (0.13 g, 0.45 mmol)  $Cs_2CO_3$  (0.3 g, 0.9 mmol), and  $Et_3N$  (0.06 g, 0.6 mmol) in DMF (6 mL) was stirred at 70 °C under nitrogen for 20 h. The reaction mixture was diluted with water, extracted with ether (3x), dried ( $Na_2SO_4$ ) and concentrated. The product was  
15 purified by column chromatography (EtOAc/Acetone as solvent) to give 0.05 g of product as a white solid. The solid was dissolved in TFA (3.0 mL) and stirred at 20 °C for 2 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a yellow solid was formed. The yellow solid was collected through filtration, washed with water and dried under  
20 vacuum to give 0.03 g (75%) of **Cmd 74** as a yellow solid;  $^1H$  NMR (300 MHz,  $CD_3OD$ )  $\delta$  8.87 (s, 1 H), 8.72 (s, 1 H), 8.66 (s, 1 H), 8.46 (s, 1 H), 8.15 (s, 1 H), 7.99 (s, 1 H), 7.66 (m, 1 H), 7.30 (m, 1 H), 7.00 (m, 1 H), 3.52 (m, 4 H), 2.00 (m, 4 H); MS (ES)  $m/z$ : 395 ( $M+H^+$ ).

25

## EXAMPLE 81

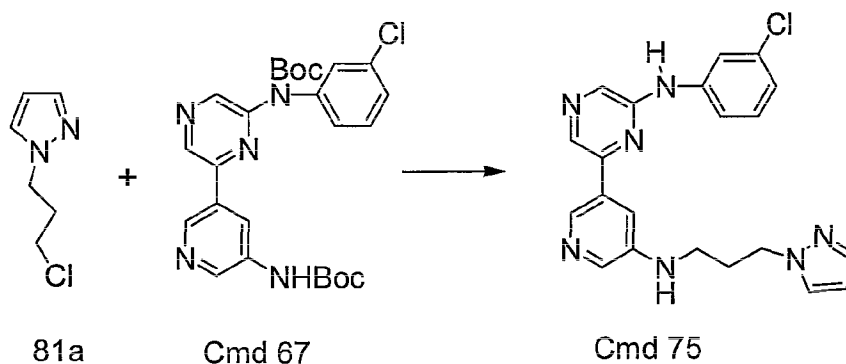
## COMPOUND 75



*N*-(3-chlorophenyl)-6-[5-[[3-(1*H*-pyrazol-1-yl)propyl]amino]-3-pyridinyl]-2-pyrazinamine (**Cmd 75**)

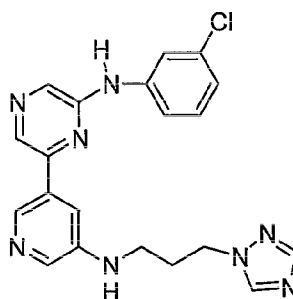
1-Bromo-3-chloropropane (11.3 g, 72 mmol) was added dropwise to a vigorously stirred ice-cooled mixture of pyrazole (5.0 g, 73 mmol), K<sub>2</sub>CO<sub>3</sub> (10.0 g, 73 mmol) and acetone (95 mL). After 3 h cooling bath was removed and the reaction mixture stirred at 20 °C for 5 days, then filtered. The filtrate was concentrated and product was purified by column chromatography (using EtOAc/hexane as solvent) to give 3.3 g (31%) of Compound **81a** as a clear oil;

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 7.52 (d, *J* = 1.5 Hz, 1 H), 7.42 (d, *J* = 2.1 Hz, 1 H), 6.24 (t, *J* = 2.0 Hz, 1 H), 4.32 (t, *J* = 6.4 Hz, 2 H), 3.45 (t, *J* = 6.0 Hz, 2 H), 2.32 (m, 2 H); MS (ES) *m/z*: 145 (M+H<sup>+</sup>). A mixture of **Cmd 67** (prepared as described in Example 6) (0.15 g, 0.3 mmol), 1-(3-chloropropyl)pyrazole Compound **81a** (0.065 g, 0.45 mmol) and Cs<sub>2</sub>CO<sub>3</sub> (0.3 g, 0.9 mmol), in DMF (6 mL) was stirred at 70 °C under nitrogen for 20 h. The reaction mixture was diluted with water, extracted with ether (3x), dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. The product was purified by column chromatography (EtOAc/Acetone as solvent) to give 0.12 g of product as an oil. The oil was dissolved in TFA (3.0 mL) and stirred at 20 °C for 2 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a solid was formed. The solid was extracted with CH<sub>2</sub>Cl<sub>2</sub>, dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. Product was purified by column chromatography (CH<sub>2</sub>Cl<sub>2</sub>/MeOH as solvent) to give 0.072 g (90%) of **Cmd 75** as an off white solid; <sup>1</sup>H NMR (300 MHz, CD<sub>3</sub>OD) δ 8.43 (s, 2 H), 8.10 (d, *J* = 7.9 Hz, 2 H), 7.98 (s, 1 H), 7.60 (m, 4 H), 7.27 (t, *J* = 8.0 Hz, 1 H), 6.98 (d, *J* = 7.9 Hz, 1 H), 6.26 (s, 1 H), 4.31 (t, *J* = 6.7 Hz, 2 H), 3.19 (t, *J* = 6.7 Hz, 2 H), 2.19 (m, 2 H); MS (ES) *m/z*: 406 (M+H<sup>+</sup>). Anal. Calcd. For C<sub>21</sub>H<sub>20</sub>N<sub>7</sub>Cl • 0.3 H<sub>2</sub>O : C, 61.33; H, 5.05; N, 23.84. Found: C, 61.38; H, 4.94; N, 23.75.



## EXAMPLE 82

## COMPOUND 76



5

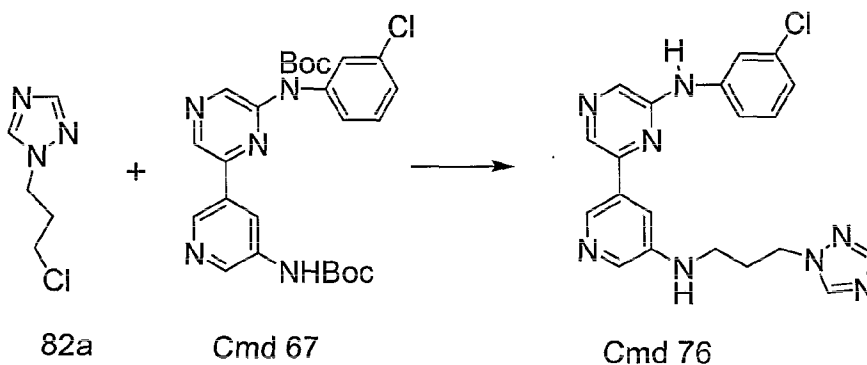
*N*-(3-chlorophenyl)-6-[5-[[3-(1*H*-1,2,4-triazol-1-yl)propyl]amino]-3-pyridinyl]-2-pyrazinamine (Compound 76)

1-Bromo-3-chloropropane (11.3 g, 72 mmol) was added dropwise under N<sub>2</sub> to a vigorously stirred ice-cooled mixture of 1,2,4-triazole (5.0 g, 72 mmol), K<sub>2</sub>CO<sub>3</sub> (10.0 g, 73 mmol) and acetone (95 mL). After 3 h, cooling bath was removed and the reaction mixture stirred at 20 °C for 5 days, then filtered. The filtrate was concentrated and product was purified by column chromatography (EtOAc/hexane as solvent) to give 7.1 g (68%) of Compound 82a as a clear oil; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.11 (s, 1 H), 7.96 (s, 1 H), 4.38 (t, *J* = 6.4 Hz, 2 H), 3.48 (t, *J* = 6.0 Hz, 2 H), 2.35 (m, 2 H); MS (ES) *m/z*: 146 (*M*+H<sup>+</sup>). A mixture of Compound 67 (prepared as described in Example 6) (0.15 g, 0.3 mmol), 1-(3-chloropropyl)-1,2,4-triazole Compound 82a (0.066 g, 0.45 mmol) and Cs<sub>2</sub>CO<sub>3</sub> (0.3 g, 0.9 mmol), in DMF (6 mL) was stirred at 70 °C under nitrogen for 20 h. The reaction mixture was diluted with water, extracted with ether (3x), dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. The product was purified by column chromatography (EtOAc/Acetone as solvent) to give 0.15 g of product as an oil. The oil was dissolved in TFA (3.0 mL) and stirred at 20 °C for 2 h before



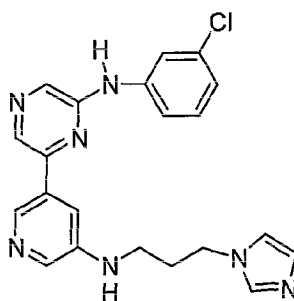
concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a solid was formed. The solid was then extracted with  $\text{CH}_2\text{Cl}_2$ , dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. Product was purified by column chromatography ( $\text{CH}_2\text{Cl}_2/\text{MeOH}$  as solvent) to give 0.086 g (86%) of **Cmd 76** as a yellow solid;  $^1\text{H}$  NMR (300 MHz,  $\text{D}^6$ -DMSO)  $\delta$  9.85 (s, 1 H), 8.59 (s, 1 H), 8.52 (s, 1 H), 8.47 (s, 1 H), 8.23 (s, 1 H), 8.12 (t,  $J = 1.9$  Hz, 1 H), 8.08 (d,  $J = 2.6$  Hz, 1 H), 7.96 (s, 1 H), 7.59 (d,  $J = 9.5$  Hz, 1 H), 7.47 (s, 1 H), 7.33 (t,  $J = 8.1$  Hz, 1 H), 7.02 (dd,  $J = 7.7, 1.6$  Hz, 1 H), 6.23 (t,  $J = 5.5$  Hz, 1 H), 4.33 (t,  $J = 6.9$  Hz, 1 H), 3.15 (m, 2 H), 2.12 (m, 2 H); MS (ES)  $m/z$ : 407 ( $\text{M} + \text{H}^+$ ). Anal.

Calcd. For  $\text{C}_{20}\text{H}_{19}\text{N}_8\text{Cl} \cdot 0.4 \text{ H}_2\text{O}$ : C, 58.01; H, 4.82; N, 27.06. Found: C, 58.25; H, 4.67; N, 26.90.



## EXAMPLE 83

## COMPOUND 77



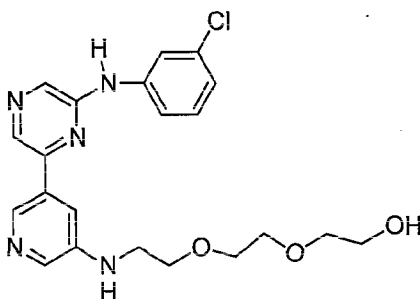
*N*-(3-chlorophenyl)-6-[5-[[3-(1H-imidazol-1-yl)propyl]amino]-3-pyridinyl]-2-pyrazinamine (**Cmd 77**)

A mixture of **Cmd 67** (prepared as described in Example 6) (0.15 g, 0.3 mmol), 1-(3-chloropropyl)imidazole (0.065 g, 0.45 mmol) and  $\text{Cs}_2\text{CO}_3$  (0.3 g, 0.9 mmol), in DMF (6 mL) was stirred at 70 °C under nitrogen for 20 h. The reaction mixture was diluted with water, extracted with ether (3x), dried

(Na<sub>2</sub>SO<sub>4</sub>) and concentrated. The product was purified by column chromatography (EtOAc/MeOH as solvent) to give 0.15 g of product as an oil. The oil was dissolved in TFA (3.0 mL) and stirred at 20 °C for 2 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a yellow solid was formed. The yellow solid was collected through filtration, washed with water and dried under vacuum to give 0.064 g (64%) of **Cmd 77** as a yellow solid; <sup>1</sup>H NMR (300 MHz, CD<sub>3</sub>OD) δ 8.42 (s, 2 H), 8.00 (m, 4 H), 7.58 (s, 1 H), 7.48 (d, *J* = 8.2 Hz, 1 H), 7.26 (t, *J* = 8.0 Hz, 2 H), 7.07 (brs, 1 H), 6.98 (d, *J* = 7.4 Hz, 1 H), 4.23 (t, *J* = 6.8 Hz, 2 H), 3.22 (t, *J* = 6.5 Hz, 2 H), 2.18 (m, 2 H); MS (ES) *m/z*: 406 (M+H<sup>+</sup>).

## EXAMPLE 84

## COMPOUND 78



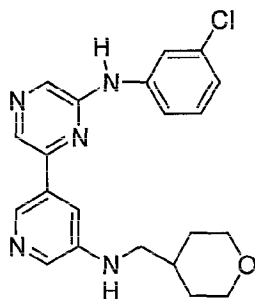
2-[2-[2-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]ethoxy]ethoxy]-ethanol (**Cmd 78**)

A mixture of **Cmd 67** (prepared as described in Example 6) (0.1 g, 0.2 mmol), (2-chloroethoxy)ethoxyethanol (0.05 g, 0.3 mmol) and Cs<sub>2</sub>CO<sub>3</sub> (0.197 g, 0.6 mmol) in DMF (4 mL) was stirred at 70 °C under nitrogen for 20 h. The reaction mixture was diluted with water, extracted with ether (3x), dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. The product was purified by column chromatography (EtOAc/Acetone as solvent) to give 0.03 g of product as an oil. The oil was dissolved in TFA (2.0 mL) and stirred at 20 °C for 2 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a yellow solid was formed. The yellow solid was collected through filtration, washed with water and dried under vacuum to give 0.012 g (60%) of **Cmd 78** as a light yellow solid; <sup>1</sup>H NMR (300 MHz, D<sup>6</sup>-DMSO) δ 9.87 (s, 1 H), 8.60 (s, 1 H), 8.47 (s, 1 H), 8.23 (s, 1 H), 8.13 (d, *J* = 8.3 Hz, 2 H), 7.59 (m, 2 H), 7.37 (t, *J* = 8.0 Hz, 1 H), 7.04 (d, *J* = 7.7 Hz, 1 H), 6.18

(brs, 1 H), 3.63 (t,  $J = 5.4$  Hz, 2 H), 3.54 (dd,  $J = 10.0, 3.6$  Hz, 4 H), 3.44 (m, 6 H); MS (ES)  $m/z$ : 430 ( $M+H^+$ ).

## EXAMPLE 85

## COMPOUND 79



*N*-(3-chlorophenyl)-6-[5-[[[(tetrahydro-2*H*-pyran-4-yl)methyl]amino]-3-pyridinyl]-2-pyrazinamine (Cmd 79)

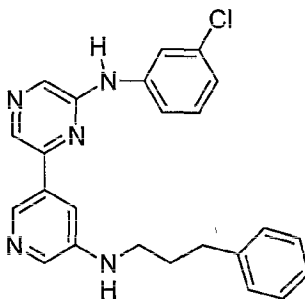
A mixture of **Cmd 67** (prepared as described in Example 6) (0.1 g, 0.2 mmol), tetrahydropyranyl-4-methanesulfonate ester (0.04 g, 0.3 mmol, Caldwell, William WO9900385) and  $\text{Cs}_2\text{CO}_3$  (0.197 g, 0.6 mmol) in DMF (4 mL) was stirred at 70 °C under nitrogen for 20 h. The reaction mixture was diluted with water, extracted with ether (3x), dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. The product was purified by column chromatography (EtOAc/Acetone as solvent) to give 0.062 g of product as an oil. The oil was dissolved in TFA (2.0 mL) and stirred at 20 °C for 2 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11. The aqueous layer was extracted with  $\text{CH}_2\text{Cl}_2$ , dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. Product was purified by column chromatography (EtOAc/MeOH as solvent) to give 0.034 g (83%) of **Cmd 79** as an off white solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  8.53 (m, 2 H), 8.17 (s, 1 H), 8.10 (d,  $J = 2.6$  Hz, 1 H), 7.90 (brs, 1 H), 7.53 (t,  $J = 2.2$  Hz, 1 H), 7.29 (m, 2 H), 7.07 (m, 1 H), 6.69 (s, 1 H), 4.02 (dd,  $J = 11.3, 4.3$  Hz, 2 H), 3.92 (brs, 1 H), 3.40 (td,  $J = 11.9, 1.8$  Hz, 2 H), 3.17 (t,  $J = 6.0$  Hz, 2 H), 1.90 (m, 1 H), 1.74 (brd,  $J = 12.8$  Hz, 2 H), 1.42 (qd,  $J = 12.2, 4.2$  Hz, 2 H); MS (ES)  $m/z$ : 396 ( $M+H^+$ ).

Anal. Calcd. For  $\text{C}_{21}\text{H}_{22}\text{N}_5\text{ClO} \cdot 0.2 \text{ H}_2\text{O}$ : C, 63.14; H, 5.65; N, 17.53. Found: C, 62.87; H, 5.47; N, 17.54.

## EXAMPLE 86

## COMPOUND 80

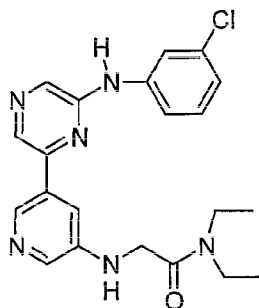
114



A mixture of **Cmd 67** (prepared as described in Example 6) (0.1 g, 0.2 mmol), 1-chloro-3-phenylpropane (0.047 g, 0.3 mmol) and  $\text{Cs}_2\text{CO}_3$  (0.197 g, 0.6 mmol) in DMF (4 mL) was stirred at 70 °C under nitrogen for 20 h. The reaction mixture was diluted with water, extracted with ether (3x), dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. The product was purified by column chromatography (EtOAc as solvent) to give 0.070 g of product as an oil. The oil was dissolved in TFA (2.0 mL) and stirred at 20 °C for 2 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11. The aqueous layer was extracted with  $\text{CH}_2\text{Cl}_2$ , dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. Product was purified by column chromatography ( $\text{CH}_2\text{Cl}_2$ /Hexane solvent) to give 0.022 g (47%) of **Cmd 80** as an off white solid;  $^1\text{H}$  NMR (300 MHz,  $\text{D}^6$ -DMSO)  $\delta$  9.85 (s, 1 H), 8.58 (s, 1 H), 8.45 (brs, 1 H), 8.22 (s, 1 H), 8.16 (s, 1 H), 8.09 (brs, 1 H), 7.56 (d,  $J = 8.0$  Hz, 1 H), 7.47 (s, 1 H), 7.26 (m, 6 H), 7.02 (d,  $J = 7.9$  Hz, 1 H), 6.19 (t,  $J = 5.5$  Hz, 1 H), 3.17 (m, 2 H), 2.72 (t,  $J = 7.4$  Hz, 2 H), 1.89 (m, 2 H); MS (ES)  $m/z$ : 416 ( $\text{M} + \text{H}^+$ ). Anal. Calcd. For  $\text{C}_{24}\text{H}_{22}\text{N}_5\text{Cl} \cdot 0.1 \text{ H}_2\text{O}$ : C, 69.01; H, 5.36; N, 16.77. Found: C, 68.64; H, 5.22; N, 16.49.

## EXAMPLE 87

## COMPOUND 81

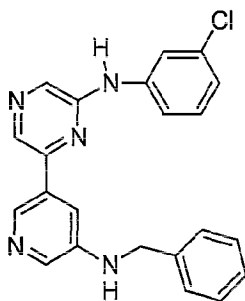


A mixture of **Cmd 67** (prepared as described in Example 6) (0.1 g, 0.2 mmol), 2-chloro-N,N-diethylacetamide (0.045 g, 0.3 mmol) and  $\text{Cs}_2\text{CO}_3$  (0.197

- g, 0.6 mmol) in DMF (4 mL) was stirred at 70 °C under nitrogen for 20 h. The reaction mixture was diluted with water, extracted with ether (3x), dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. The product was purified by column chromatography (EtOAc/Acetone as solvent) to give 0.1 g of product as an oil.
- 5 The oil was dissolved in TFA (2.0 mL) and stirred at 20 °C for 2 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a yellow solid was formed. The aqueous layer was extracted with  $\text{CH}_2\text{Cl}_2$ . The yellow solid went into the organic layer and was dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. Product was purified by column
- 10 chromatography (EtOAc/MeOH as solvent) to give 0.042 g (63%) of **Cmd 81** as a yellow solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  8.57 (s, 1 H), 8.51 (s, 1 H), 8.18 (s, 1 H), 8.15 (d,  $J = 2.6$  Hz, 1 H), 7.84 (t,  $J = 2.0$  Hz, 1 H), 7.48 (t,  $J = 2.0$  Hz, 1 H), 7.32 (m, 2 H), 7.05 (d,  $J = 7.8$  Hz, 1 H), 6.84 (s, 1 H), 5.26 (brs, 1 H), 3.97 (d,  $J = 4.1$  Hz, 2 H), 3.48 (q,  $J = 7.1$  Hz, 2 H), 3.35 (q,  $J = 7.1$  Hz, 2 H), 1.26 (t,
- 15  $J = 7.1$  Hz, 6 H); MS (ES)  $m/z$ : 411 ( $\text{M} + \text{H}^+$ ).

## EXAMPLE 88

## COMPOUND 82



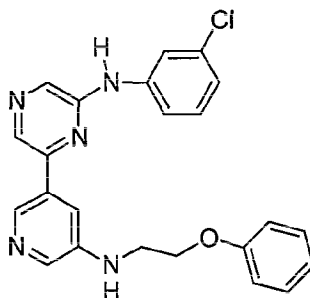
- 20 A mixture of **Cmd 67** (prepared as described in Example 6) (0.1 g, 0.2 mmol), benzyl bromide (0.05 g, 0.3 mmol) and  $\text{Cs}_2\text{CO}_3$  (0.197 g, 0.6 mmol) in DMF (4 mL) was stirred at 70 °C under nitrogen for 20 h. The reaction mixture was diluted with water, extracted with ether (3x), dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. The product was purified by column chromatography
- 25 (EtOAc/Hexane as solvent) to give 0.025 g of product as an oil. The oil was dissolved in TFA (2.0 mL) and stirred at 20 °C for 2 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11. The aqueous layer was extracted with  $\text{CH}_2\text{Cl}_2$ , dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. Product was triturated with  $\text{CH}_2\text{Cl}_2$ /Hexane to give clean product

0.011 g (69%) of **Cmd 82** as a yellow solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  8.58 (s, 1 H), 8.48 (s, 1 H), 8.15 (d,  $J=4.9$  Hz, 2 H), 7.85 (s, 1 H), 7.57 (s, 1 H), 7.35 (m, 6 H), 7.05 (d,  $J=6.8$  Hz, 2 H), 6.67 (brs, 1 H), 4.46 (d,  $J=5.4$  Hz, 2 H), 4.26 (brs, 1 H); MS (ES)  $m/z$ : 388 ( $\text{M}+\text{H}^+$ ).

5

## EXAMPLE 89

## COMPOUND 83

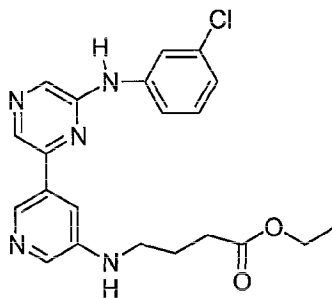


A mixture of **Cmd 67** (prepared as described in Example 6) (0.1 g, 0.2 mmol), beta-bromophenetole (0.061 g, 0.3 mmol) and  $\text{Cs}_2\text{CO}_3$  (0.197 g, 0.6 mmol) in DMF (4 mL) was stirred at 70 °C under nitrogen for 20 h. The reaction mixture was diluted with water, extracted with ether (3x), dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. The product was purified by column chromatography (EtOAc as solvent) to give 0.12 g of product as an oil. The oil was dissolved in TFA (2.0 mL) and stirred at 20 °C for 2 h before being concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a yellow solid was formed. The aqueous layer was extracted with  $\text{CH}_2\text{Cl}_2$ . The yellow solid went into the organic layer and was dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. Product was triturated with  $\text{CH}_2\text{Cl}_2$  to give clean product 0.055 g (68%) of **Cmd 83** as a yellow solid;  $^1\text{H}$  NMR (300 MHz,  $\text{D}^6$ -DMSO)  $\delta$  9.85 (s, 1 H), 8.61 (s, 1 H), 8.49 (s, 1 H), 8.23 (s, 1 H), 8.14 (s, 1 H), 7.66 (m, 2 H), 7.31 (m, 3 H), 6.98 (m, 4 H), 6.39 (brs, 1 H), 4.19 (t,  $J=5.2$  Hz, 2 H), 3.59 (d,  $J=5.3$  Hz, 2 H); MS (ES)  $m/z$ : 418 ( $\text{M}+\text{H}^+$ ). Anal. Calcd. For  $\text{C}_{23}\text{H}_{20}\text{N}_5\text{ClO}\cdot 0.2 \text{H}_2\text{O}$ : C, 65.54; H, 4.88; N, 16.62. Found: C, 65.35; H, 4.72; N, 16.32.

25

## EXAMPLE 90

## COMPOUND 84

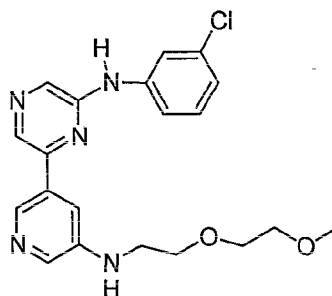


4-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-  
3-pyridinyl]amino]-butanoic acid ethyl ester (**Cmd 84**)

A mixture of **Cmd 67** (prepared as described in Example 6) (0.1 g, 0.2 mmol), ethyl-4-bromobutyrate (0.059 g, 0.3 mmol) and  $\text{Cs}_2\text{CO}_3$  (0.197 g, 0.6 mmol) in DMF (4 mL) was stirred at 70 °C under nitrogen for 20 h. The reaction mixture was diluted with water, extracted with ether (3x), dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. The product was purified by column chromatography (EtOAc/Acetone as solvent) to give 0.013 g of product as an oil. The oil was dissolved in TFA (2.0 mL) and stirred at 20 °C for 2 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a solid was formed. The aqueous layer was extracted with  $\text{CH}_2\text{Cl}_2$ . The yellow solid went into the organic layer and was dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. Product was triturated with  $\text{CH}_2\text{Cl}_2$ /Hexane to give clean product 0.004 g (46%) of **Cmd 84** as an off white solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  8.53 (m, 2 H), 8.17 (s, 1 H), 8.09 (brs, 1 H), 7.86 (s, 1 H), 7.54 (s, 1 H), 7.33 (m, 2 H), 7.06 (m, 1 H), 6.69 (s, 1 H), 4.15 (q,  $J = 7.1$  Hz, 2 H), 4.08 (brs, 1 H), 3.32 (m, 2 H), 2.47 (t,  $J = 7.0$  Hz, 2 H) 2.03 (m, 2 H), 1.26 (t,  $J = 7.2$  Hz, 3 H); MS (ES)  $m/z$ : 412 ( $\text{M} + \text{H}^+$ ).

20

#### EXAMPLE 91 COMPOUND 85



*N*-(3-chlorophenyl)-6-[5-[[2-(2-methoxyethoxy)ethyl]amino]-

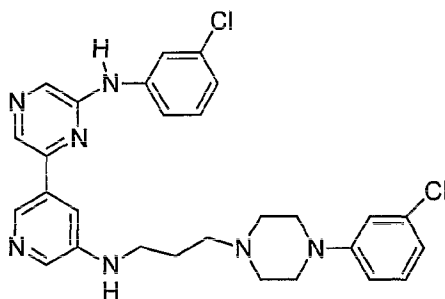
## 3-pyridinyl]-2-pyrazinamine (Cmd 85)

A mixture of **Cmd 67** (prepared as described in Example 6) (0.1 g, 0.2 mmol), 1-bromo-2-(2-methoxyethoxy)ethane (0.055 g, 0.3 mmol) and  $\text{Cs}_2\text{CO}_3$  (0.197 g, 0.6 mmol) in DMF (4 mL) was stirred at 70 °C under nitrogen for 20 h.

- 5 The reaction mixture was diluted with water, extracted with ether (3x), dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. The product was purified by column chromatography (EtOAc/Acetone as solvent) to give 0.1 g of product as an oil. The oil was dissolved in TFA (2.0 mL) and stirred at 20 °C for 2 h before concentrated. Ammonium hydroxide solution was added to the residue until the
- 10 pH was about 10-11 and a solid was formed. The aqueous layer was extracted with  $\text{CH}_2\text{Cl}_2$ . The yellow solid went into the organic layer and was dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. Product was purified by column chromatography (EtOAc/Acetone as solvent) to give 0.058 g (87%) of **Cmd 85** as a light yellow solid;  $^1\text{H}$  NMR (300 MHz,  $\text{D}^6$ -DMSO)  $\delta$  9.85 (s, 1 H), 8.60 (s, 1 H), 8.47 (brs, 1 H), 8.23 (s, 1 H), 8.14 (s, 1 H), 7.59 (m, 2 H), 7.37 (t,  $J = 8.0$  Hz, 1 H), 7.03 (d,  $J = 8.0$  Hz, 1 H), 6.16 (brs, 1 H), 3.63 (t,  $J = 5.6$  Hz, 2 H), 3.56 (m, 2 H), 3.45 (m, 2 H), 3.32 (m, 2 H), 3.22 (s, 3 H); MS (ES)  $m/z$ : 400 ( $\text{M}+\text{H}^+$ ). Anal. Calcd. For  $\text{C}_{20}\text{H}_{22}\text{N}_5\text{ClO}_2$ : C, 60.07; H, 5.55; N, 17.51. Found: C, 59.92; H, 5.41; N, 17.40.
- 15
- 20

## EXAMPLE 92

## COMPOUND 86



- A mixture of **Cmd 67** (prepared as described in Example 6) (0.1 g, 0.2 mmol), 1-(3-chlorophenyl)-4-(3-chloropropyl)piperazine (0.093 g, 0.3 mmol) and  $\text{Cs}_2\text{CO}_3$  (0.197 g, 0.6 mmol) in DMF (4 mL) was stirred at 70 °C under nitrogen for 20 h. The reaction mixture was diluted with water, extracted with ether (3x), dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. The product was purified by column chromatography (EtOAc/Acetone as solvent) to give 0.078 g of product
- 25



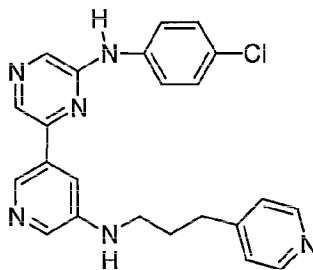
as an oil. The oil was dissolved in TFA (2.0 mL) and stirred at 20 °C for 2 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11. The aqueous layer was extracted with CH<sub>2</sub>Cl<sub>2</sub>, dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. Product was purified by column

5 chromatography (EtOAc/MeOH as solvent) to give 0.042 g (75%) of **Cmd 86** as a light yellow solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.51 (s, 2 H), 8.15 (s, 1 H), 8.08 (s, 1 H), 7.91 (s, 1 H), 7.54 (s, 1 H), 7.26 (m, 2 H), 7.15 (t, *J* = 8.0 Hz, 1 H), 7.04 (m, 1 H), 6.79 (m, 4 H), 5.06 (brs, 1 H), 3.37 (t, *J* = 6.1 Hz, 2 H), 3.20 (t, *J* = 5.0 Hz, 4 H), 2.60 (m, 6 H), 1.89 (m, 2 H); MS (ES) *m/z*: 534 (M+H<sup>+</sup>).

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## EXAMPLE 93

## COMPOUND 87



A mixture of Compound **1D** (2.7 g, 10.24 mmol), 4-chloroaniline (1.3 g, 15.35 mmol), Pd<sub>2</sub>(dba)<sub>3</sub> (0.265 g, 0.26 mmol), DPPF (0.45 g, 0.81 mmol), Cs<sub>2</sub>CO<sub>3</sub> (6.67 g, 24.48 mmol) in anhydrous dioxane (50 mL) was stirred at 100 °C overnight under nitrogen. Dichloromethane (100 mL) was added to the cooled reaction mixture, which was then filtered through celite. The celite cake was washed with more dichloromethane and the combined filtrate was

20 concentrated to give a yellow solid. The solid was purified by column chromatography (EtOAc/hexane as solvent) to give 2.0 g (56%) of Compound **93a** as a yellow solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.40 (d, *J* = 2.1 Hz, 1 H), 9.29 (d, *J* = 1.9 Hz, 1 H), 8.87 (t, *J* = 2.0 Hz, 1 H), 8.55 (s, 1 H), 8.22 (s, 1 H), 7.52 (d, *J* = 8.7 Hz, 2 H), 7.35 (d, *J* = 8.7 Hz, 2 H), 6.71 (s, 1 H), 4.47 (q, *J* = 7.1 Hz, 2 H), 1.44 (t, *J* = 7.1 Hz, 3 H); MS (ES) *m/z*: 355 (M+H<sup>+</sup>). Compound **93a** (1.5 g, 4.2 mmol) was dissolved in CH<sub>2</sub>Cl<sub>2</sub> (80 mL), and treated with Boc<sub>2</sub>O (1.8 g, 8.4 mmol) and DMAP (catalytic amount). The reaction mixture was stirred at 20 °C under nitrogen for 2 h. The solvent was removed under vacuum and the product was purified by column chromatography (EtOAc/Hex as

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solvent) to give 1.23 g (65%) of Compound **93b** as a hard foam. <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.25 (d, *J* = 2.0 Hz, 1 H), 9.16 (d, *J* = 1.9 Hz, 1 H), 9.10 (s, 1 H), 8.82 (s, 1 H), 8.62 (t, *J* = 2.0 Hz, 1 H), 7.40 (d, *J* = 8.8 Hz, 2 H), 7.18 (d, *J* = 8.7 Hz, 2 H), 4.45 (q, *J* = 7.1 Hz, 2 H), 1.50 (s, 9 H), 1.44 (t, *J* = 7.1 Hz, 3 H); MS (ES) *m/z*: 455 (M+H<sup>+</sup>).

Compound **93b** (1.23 g, 2.7 mmol) was treated with MeOH (26 mL). After 3 min 1 N NaOH<sub>(aq)</sub> (22 mL) was added and the reaction mixture was stirred at 20° C for 4 h. Glacial acetic acid and water were added to the reaction mixture until a yellow solid was formed. The solid was filtered and washed with water and dried under vacuum to give 1.08 g (94%) of Compound **93c** as a yellow solid. Compound **93c** (0.5 g, 1.12 mmol), Et<sub>3</sub>N (0.24 g, 2.3 mmol), DPPA (1.44 mol), and t-BuOH (5mL) in toluene (4 mL) was stirred at 70° C for 40 min under N<sub>2</sub> and then at 100° C for 4 h. The solvent was removed under reduced pressure and product was purified by column chromatography (EtOAc/Hex as solvent) to give 0.32 g (55%) of Compound **93d** as a hard foam; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.02 (s, 1 H), 8.78 (s, 1 H), 8.68 (d, *J* = 1.8 Hz, 1 H), 8.44 (d, *J* = 2.4 Hz, 2 H), 7.38 (d, *J* = 8.7 Hz, 2 H), 7.22 (d, *J* = 8.7 Hz, 2 H), 6.56 (brs, 1 H), 1.55 (s, 9 H), 1.48 (s, 9 H); MS (ES) *m/z*: 498 (M+H<sup>+</sup>).

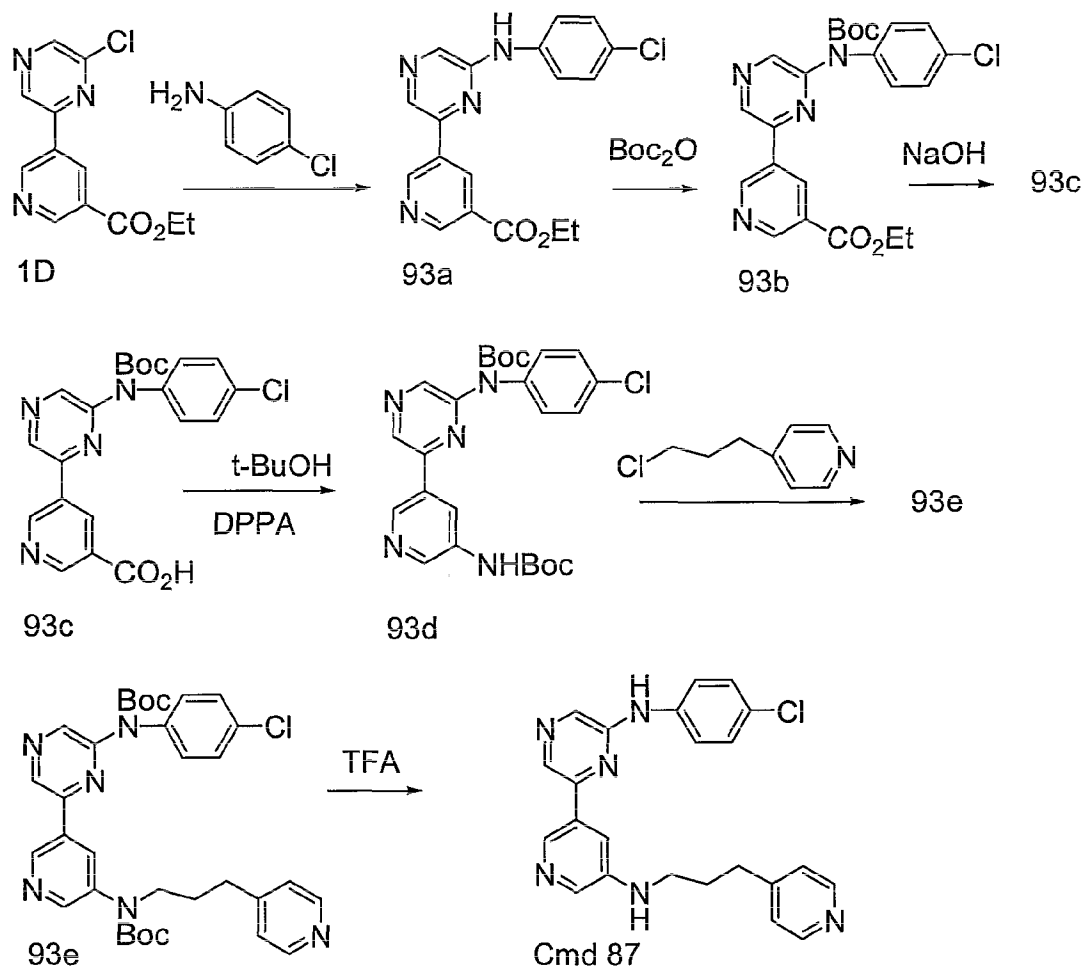
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A mixture of Compound **93d** (0.1 g, 0.2 mmol), 4-(3-chloropropyl)pyridine (0.047 g, 0.3 mmol) and Cs<sub>2</sub>CO<sub>3</sub> (0.197 g, 0.6 mmol) in DMF (4 mL) was stirred at 70 °C under nitrogen for 20 h. The reaction mixture was diluted with water, extracted with ether (3x), dried (Na<sub>2</sub>SO<sub>4</sub>) and concentrated. The product Compound **93e** was purified by column chromatography (EtOAc/MeOH as solvent) to give 0.071 g (59%) of product as an oil. The oil was dissolved in TFA (2.0 mL) and stirred at 20 °C for 2 h before being concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a solid was formed. The yellow solid was collected through filtration, washed with water and dried. Clean product was obtained by recrystallization (CH<sub>2</sub>Cl<sub>2</sub>/Hexane) to give 0.038 g (79%) of **Cmd 87** as a light yellow solid; <sup>1</sup>H NMR (300 MHz, CD<sub>3</sub>OD) δ 8.39 (m, 4 H), 8.10 (s, 1 H), 7.98 (s, 1 H), 7.77 (m, 2 H), 7.61 (s, 1 H), 7.33 (d, *J* = 6.1 Hz, 2 H), 7.27 (dd, *J* = 6.9, 2.1 Hz, 2 H), 3.25 (t, *J* = 6.8 Hz, 2 H), 2.84 (t, *J* = 7.6 Hz, 2 H),

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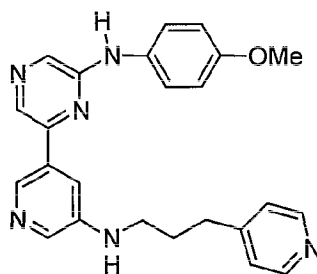
121

2.04 (m, 2 H); MS (ES) m/z: 417 (M+H<sup>+</sup>).



### EXAMPLE 94

COMPOUND 88



*N*-(4-methoxyphenyl)-6-[5-[[3-(4-pyridinyl)propyl]amino]-3-pyridinyl]-2-pyrazinamine (Cmd **88**)

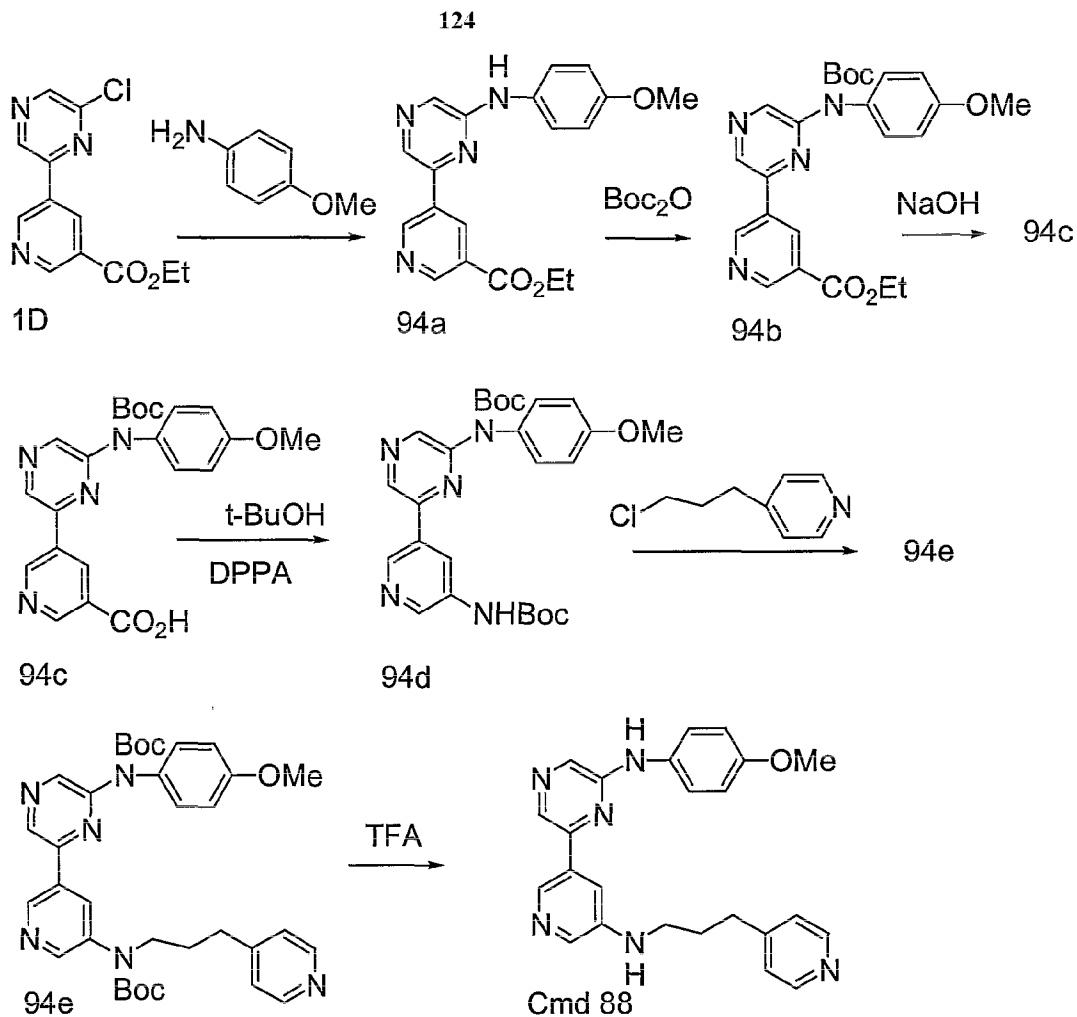
A mixture of Compound **1D** (2.7 g, 10.24 mmol), p-anisidine (1.89 g, 15.35 mmol), Pd<sub>2</sub>(dba)<sub>3</sub> (0.265 g, 0.26 mmol), DPPF (0.45 g, 0.81 mmol), Cs<sub>2</sub>CO<sub>3</sub> (6.67 g, 24.48 mmol) in anhydrous dioxane (50 mL) was stirred at 100 °C overnight under nitrogen. Dichloromethane (100 mL) was added to the

cooled reaction mixture, which was then filtered through celite. The celite cake was washed with more dichloromethane and the combined filtrate was concentrated to give a yellow solid. The solid was purified by column chromatography (EtOAc/hexane as solvent) to give 2.1 g (58%) of Compound **94a** as a solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.39 (d,  $J = 2.1$  Hz, 1 H), 9.27 (d,  $J = 1.9$  Hz, 1 H), 8.86 (t,  $J = 2.0$  Hz, 1 H), 8.47 (s, 1 H), 8.12 (s, 1 H), 7.40 (d,  $J = 8.8$  Hz, 2 H), 6.95 (d,  $J = 8.8$  Hz, 2 H), 6.50 (s, 1 H), 4.46 (q,  $J = 7.1$  Hz, 2 H), 3.84 (s, 3 H), 1.45 (t,  $J = 7.1$  Hz, 3 H); MS (ES)  $m/z$ : 351 ( $\text{M} + \text{H}^+$ ). Anal. Calcd. For  $\text{C}_{19}\text{H}_{18}\text{N}_4\text{O}_3 \cdot 0.5 \text{H}_2\text{O}$ : C, 63.90; H, 5.22; N, 15.18. Found: C, 63.50; H, 5.33; N, 15.59.

Compound **94a** (1.7 g, 4.8 mmol) was dissolved in  $\text{CH}_2\text{Cl}_2$  (100 mL), and treated with  $\text{Boc}_2\text{O}$  (2.1 g, 9.7 mmol) and DMAP (catalytic amount). The reaction mixture was stirred at 20 °C under nitrogen for 3 h. The solvent was removed under vacuum and the product was purified by column chromatography (EtOAc/Hex as solvent) to give 1.92 g (88%) of Compound **94b** as a hard foam;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.22 (d,  $J = 2.1$  Hz, 1 H), 9.18 (d,  $J = 1.9$  Hz, 1 H), 9.08 (s, 1 H), 8.78 (s, 1 H), 8.66 (t,  $J = 2.0$  Hz, 1 H), 7.19 (d,  $J = 8.7$  Hz, 2 H), 6.92 (d,  $J = 8.8$  Hz, 2 H), 4.45 (q,  $J = 7.1$  Hz, 2 H), 3.83 (s, 3 H), 1.49 (s, 9 H), 1.44 (t,  $J = 7.1$  Hz, 3 H); MS (ES)  $m/z$ : 451 ( $\text{M} + \text{H}^+$ ). Compound **94b** (1.92 g, 4.2 mmol) was treated with MeOH (40 mL). After 3 min, 1 N  $\text{NaOH}_{(\text{aq})}$  (32 mL) was added and the reaction mixture was stirred at 20° C for 4 h. Glacial acetic acid (25 mL) was added to the reaction mixture along with water until a yellow solid was formed. The solid was filtered and washed with water and then dried under vacuum to give 1.69 g (94%) of Compound **94c** as a yellow solid. Compound **94c** (0.5 g, 1.2 mmol),  $\text{Et}_3\text{N}$  (0.24 g, 2.3 mmol), DPPA (1.44 mol), and  $t\text{-BuOH}$  (5mL) in toluene (8 mL) was stirred at 70° C for 40 min under  $\text{N}_2$  and then at 100° C for 2 h. The solvent was removed under reduced pressure and product was purified by column chromatography (EtOAc/Hex as solvent) to give 0.45 g (77%) of Compound **94d** as a hard foam;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  8.96 (s, 1 H), 8.74 (s, 1 H), 8.70 (d,  $J = 1.7$  Hz, 1 H), 8.48 (d,  $J = 2.4$  Hz, 1 H), 8.36 (brs, 1 H), 7.20 (d,  $J = 8.8$  Hz, 2 H), 6.92 (d,  $J = 8.8$  Hz, 2 H), 6.56 (brs, 1 H), 3.82 (s, 3 H), 1.54 (s, 9 H), 1.47 (s, 9 H); MS (ES)  $m/z$ : 494 ( $\text{M} + \text{H}^+$ ).

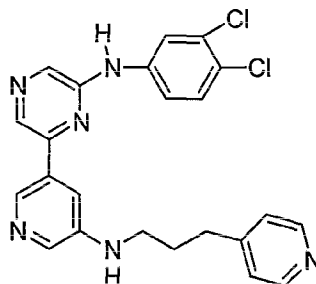
A mixture of Compound **94d** (0.15 g, 0.3 mmol), 4-(3-chloropropyl)pyridine (0.07 g, 0.45 mmol) and  $\text{Cs}_2\text{CO}_3$  (0.3 g, 0.9 mmol) in DMF (6 mL) was stirred at 70 °C under nitrogen for 20 h. The reaction mixture  
5 was diluted with water, extracted with ether (3x), dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. The product Compound **94e** was purified by column chromatography (EtOAc/MeOH as solvent) to give 0.122 g (66%) of product as an oil. The oil was dissolved in TFA (2.0 mL) and stirred at 20 °C for 2 h before concentrated. Ammonium hydroxide solution was added to the residue until the  
10 pH was about 10-11 and a solid was formed. The yellow solid was collected through filtration, washed with water and dried. Clean product was obtained by recrystallization ( $\text{CH}_2\text{Cl}_2$ /Hexane) to give 0.063 g (77%) of **Cmd 88** as a light yellow solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CD}_3\text{OD}$ )  $\delta$  8.39 (d,  $J = 4.4$  Hz, 3 H), 8.30 (s, 1 H), 8.01 (s, 1 H), 7.96 (d,  $J = 2.5$  Hz, 1 H), 7.62 (m, 3 H), 7.31 (d,  $J = 5.8$  Hz, 2 H), 6.89 (d,  $J = 9.0$  Hz, 2 H), 3.76 (s, 3 H), 3.31 (t,  $J = 1.5$  Hz, 2 H), 2.82 (t,  $J = 7.3$  Hz, 2 H), 2.03 (m, 2 H); MS (ES)  $m/z$ : 413 ( $\text{M} + \text{H}^+$ ).

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## EXAMPLE 95

## COMPOUND 89



*N*-(3,4-dichlorophenyl)-6-[5-[[3-(4-pyridinyl)propyl]amino]-3-pyridinyl]-2-pyrazinamine (Cmd 89)

A mixture of Compound 1D (2.7 g, 10.24 mmol), 3,4-dichloroaniline (1.89 g, 15.35 mmol), Pd<sub>2</sub>(dba)<sub>3</sub> (0.265 g, 0.26 mmol), DPPF (0.45 g, 0.81 mmol), Cs<sub>2</sub>CO<sub>3</sub> (6.67 g, 24.48 mmol) in anhydrous dioxane (50 mL) was stirred at 100 °C overnight under nitrogen. Dichloromethane (100 mL) was added to the

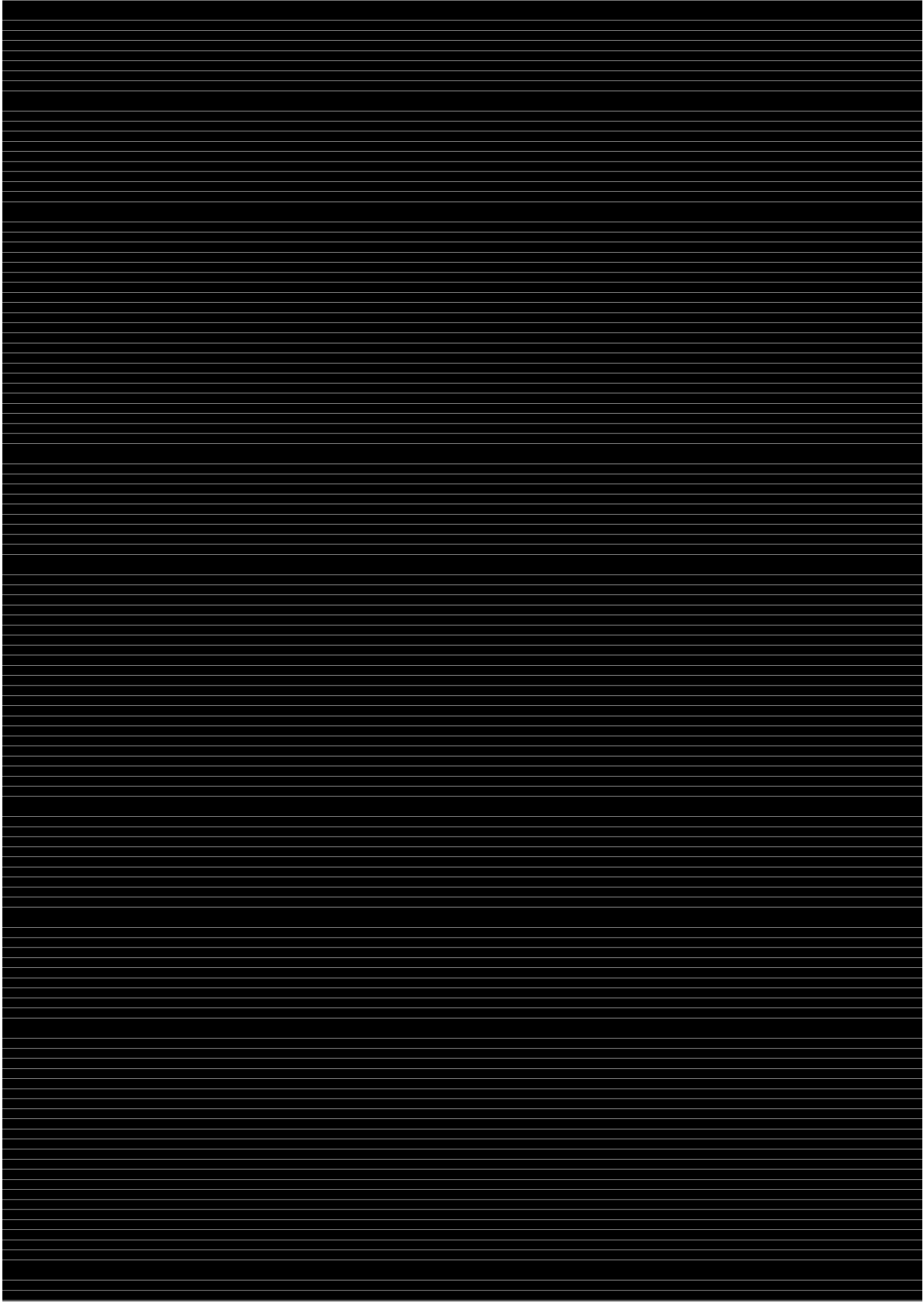
cooled reaction mixture, which was then filtered through celite. The celite cake was washed with more dichloromethane and the combined filtrate was concentrated to give a yellow solid. The solid was purified by column chromatography (EtOAc/hexane as solvent) to give 1.0 g (24%) of Compound **95a** as a solid. Compound **95a** (0.86 g, 1.77 mmol) was dissolved in CH<sub>2</sub>Cl<sub>2</sub> (35 mL), and treated with Boc<sub>2</sub>O (0.76 g, 3.54 mmol) and DMAP (catalytic amount). The reaction mixture was stirred at 20 °C under nitrogen for 3 h. The solvent was removed under vacuum and the product was purified by column chromatography (EtOAc/Hex as solvent) to give 1.0 g (93%) of Compound **95b** as a hard foam; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.24 (d, *J* = 1.8 Hz, 1 H), 9.16 (d, *J* = 2.1 Hz, 1 H), 9.09 (s, 1 H), 8.85 (s, 1 H), 8.63 (t, *J* = 2.0 Hz, 1 H), 7.50 (d, *J* = 8.5 Hz, 1 H), 7.40 (d, *J* = 2.4 Hz, 1 H), 7.14 (dd, *J* = 8.0, 1.9 Hz, 1 H), 4.44 (q, *J* = 7.1 Hz, 2 H), 1.49 (s, 9 H), 1.43 (t, *J* = 7.1 Hz, 3 H); MS (ES) *m/z*: 489 (M+H<sup>+</sup>).

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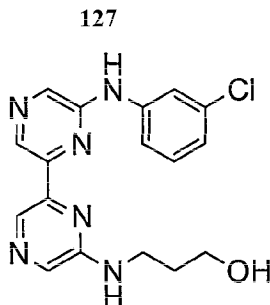
Compound **95b** (0.45 g, 0.92 mmol) was treated with MeOH (10 mL). After 3 min 1 N NaOH<sub>(aq)</sub> (8 mL) was added and the reaction mixture was stirred at 20° C for 4 h. Glacial acetic acid (7 mL) acid was added to the reaction mixture along with water until a yellow solid was formed. The solid was filtered and washed with water and dried under vacuum to give 0.38 g (90%) of Compound **95c** as a yellow solid. Compound **95c** (0.38 g, 0.83 mmol), Et<sub>3</sub>N (0.17 g, 1.7 mmol), DPPA (1.06 mol), and t-BuOH (3.7 mL) in toluene (3 mL) was stirred at 70° C for 40 min under N<sub>2</sub> and then at 100° C for 3 h. The solvent was removed under reduced pressure and product was purified by column chromatography (EtOAc/Hex as solvent) to give 0.099 g (23%) of Compound **95d** as a hard foam; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.99 (s, 1 H), 8.81 (s, 1 H), 8.69 (brs, 1 H), 8.45 (brs, 2 H), 7.49 (d, *J* = 8.6 Hz, 1 H), 7.40 (d, *J* = 2.4 Hz, 1 H), 7.16 (dd, *J* = 8.6 2.4 Hz, 1 H), 6.59 (brs, 1 H), 1.54 (s, 9 H), 1.49 (s, 9 H); MS (ES) *m/z*: 532 (M+H<sup>+</sup>).

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A mixture of Compound **95d** (0.1 g, 0.2 mmol), 4-(3-chloropropyl)pyridine (0.047 g, 0.3 mmol) and Cs<sub>2</sub>CO<sub>3</sub> (0.19 g, 0.6 mmol) in DMF (4 mL) was stirred at 70 °C under nitrogen for 20 h. The reaction mixture was diluted with water, extracted with ether (3x), dried (Na<sub>2</sub>SO<sub>4</sub>) and







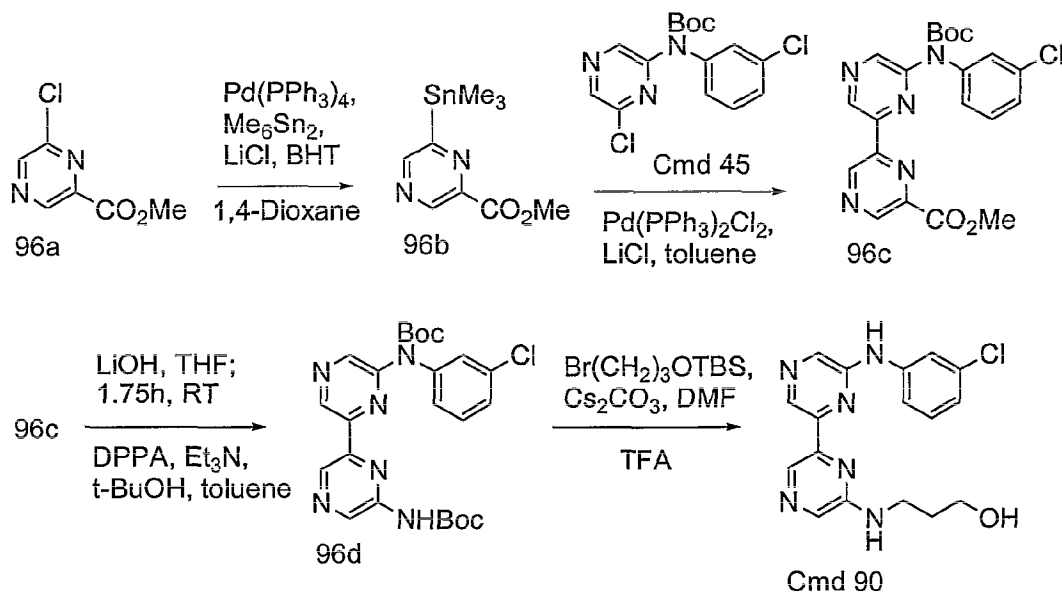
3-[[6'-[(3-chlorophenyl)amino]  
[2,2'-bipyrazin]-6-yl]amino]-1-propanol (Cmd 90)

A mixture of methyl 6-chloro-2-pyrazinecarboxylate Compound **96a** (4.50 g, 26.1 mmol; Sato, N. *J. Heterocyc. Chem.* **1994**, 31, 1177), bis(trimethyltin) (10.0 g, 30.5 mmol), tetrakis(triphenylphosphine) palladium (1.51 g, 1.31 mmol), LiCl (3.32 g, 78.3 mmol), and 2,6-di-*tert*-butyl-4-methylphenol (0.230 g, 1.04 mmol) in anhydrous 1,4-dioxane (80 mL) was refluxed at 100 °C for 4.5 h under nitrogen. After cooled to room temperature, the reaction mixture was filtered. The solid was washed with dichloromethane and the filtrate was concentrated and flash chromatographed (ethyl acetate/hexane as solvent) to give 5.60 g (71%) of methyl 6-trimethylstannyl-2-pyrazinecarboxylate Compound **96b** as a yellow oil; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.09 (s, 1 H), 8.73 (s, 1 H), 4.02 (s, 3 H), 0.44 (s, 9 H). A mixture of the methyl 6-trimethylstannyl-2-pyrazinecarboxylate Compound **96b** (536 mg, 1.78 mmol), *N*-(*tert*-butoxycarbonyl)-*N*-(3-chlorophenyl)-2-amino-6-chloropyrazine **Cmd 45** (666 mg, 1.96 mmol), dichlorobis(triphenylphosphine) palladium (125 mg, 0.178 mmol), and LiCl (230 mg, 5.42 mmol) in anhydrous toluene (15 mL) was stirred at 100 °C for 6.5 h under nitrogen. The cooled reaction mixture was concentrated under vacuum and purified by flash chromatography (EtOAc/hexane as solvent) to give 593 mg (75%) of Compound **96c** as an off-white solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.40 (s, 1 H), 9.27 (s, 1 H), 9.20 (s, 1 H), 9.17 (s, 1 H), 7.41-7.32 (m, 2 H), 7.29 (m, 1 H), 7.19-7.16 (m, 1 H), 4.07 (s, 3 H), 1.49 (s, 9 H); MS (ES) *m/z*: 464 (M+Na<sup>+</sup>). Anal. Calcd. For C<sub>21</sub>H<sub>20</sub>N<sub>5</sub>O<sub>4</sub>Cl: C, 57.08; H, 4.56; N, 15.85. Found: C, 57.02; H, 4.46; N, 15.41.

Compound **96c** (1.31 g, 2.97 mmol) was treated with LiOH (0.110 g, 4.58 mmol) in THF (10 mL) and water (2.5 mL) for 2 h at room temperature. Acetic acid (0.55 mL) was added and the solution was concentrated to about half

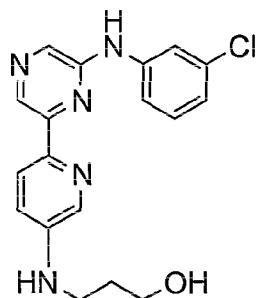
of the original volume. After the addition of water, some solid formed. The solid was collected through filtration, washed with water, and dried under vacuum overnight to give 1.22 g (96%) of a carboxylic acid as a yellow solid; MS (ES)  $m/z$ : 450 ( $M+Na^+$ ). A mixture of the carboxylic acid (350 mg, 0.819 mmol), DPPA (340 mg, 1.24 mmol), and triethylamine (0.230 mL, 1.65 mmol) in *t*-BuOH (5 mL) and toluene (4 mL) was heated at 60 °C for 30 min, then the temperature was slowly increased to 80 °C for 2 h and 90 °C for 1 h. After concentration, the reaction mixture was purified by flash chromatography (EtOAc/hexane as solvent) to give 278 mg (68%) of Compound **96d** as a yellow solid;  $^1H$  NMR (300 MHz,  $CDCl_3$ )  $\delta$  9.31 (s, 1 H), 9.23 (s, 1 H), 9.16 (s, 1 H), 8.70 (s, 1 H), 7.96 (brs, 1 H), 7.39-7.30 (m, 2 H), 7.27 (m, 1 H), 7.19-7.15 (m, 1 H), 1.57 (s, 9 H), 1.48 (s, 9 H); MS (ES)  $m/z$ : 521 ( $M+Na^+$ ).

A mixture of Compound **96d** (60 mg, 0.12 mmol), (3-bromopropoxy)-*tert*-butyldimethylsilane (40 mg, 0.16 mmol), and  $Cs_2CO_3$  (80 mg, 0.25 mmol) in dry DMF (1 mL) was heated at 70 °C for 3.5 h. The reaction mixture was concentrated and purified by column chromatography (EtOAc/hexane as solvent) to give 71 mg (88%) of the *N*-akylated product as an off-white solid; Anal. Calcd. For  $C_{33}H_{47}N_6O_5ClSi$ : C, 59.04; H, 7.06; N, 12.52. Found: C, 59.24; H, 7.00; N, 12.11. The *N*-akylated product (250 mg, 0.373 mmol) was dissolved in TFA (4 mL) and the solution was stirred at room temperature for 3 h before concentration. A saturated  $NH_4OH$  solution was added to the residue until the mixture was made basic followed by the addition of water. The precipitated solid was collected through filtration, again washed with water and dried under vacuum. The product was purified by flash chromatography on silica gel (EtOAc/MeOH as solvent) to provide 112 mg (84%) of **Cmd 90** as a yellow solid;  $^1H$  NMR (300 MHz,  $DMSO-d_6$ )  $\delta$  9.89 (s, 1 H), 8.79 (s, 1 H), 8.47 (s, 1 H), 8.28 (s, 1 H), 8.13 (s, 1 H), 8.00 (s, 1 H), 7.62 (d,  $J = 8.2$  Hz, 1 H), 7.39 (t,  $J = 8.0$  Hz, 1 H), 7.29 (m, 1 H), 7.04 (d,  $J = 8.1$  Hz, 1 H), 4.51 (brs, 1 H), 3.53 (m, 2 H), 3.47-3.41 (m, 2 H), 1.82-1.73 (m, 2 H); MS (ES)  $m/z$ : 357 ( $M+H^+$ ).



## EXAMPLE 97

## COMPOUND 91



5

A mixture of methyl 6-(trifluoromethylsulphonyloxy)nicotinate  
Compound **97a** (2.00 g, 7.02 mmol; Torrado, A. *Synthesis* **1995**, 285; *J. Org.*  
*Chem.* **1996**, 61, 8940), bis(trimethyltin) (3.50 g, 10.7 mmol),  
tetrakis(triphenylphosphine)palladium (0.810 g, 0.700 mmol), anhydrous LiCl  
(0.900 g, 21.2 mmol), and 2,6-di-*tert*-butyl-4-methylphenol (0.062 g, 0.28  
10 mmol) in anhydrous 1,4-dioxane (60 mL) was refluxed at 100 °C for 2 h under  
nitrogen. After cooled to room temperature, the reaction mixture was filtered  
through celite and washed with dichloromethane. The filtrate was concentrated  
under vacuum. Water and Et<sub>2</sub>O were added to the residue and the resulting  
mixture was filtered again through celite. The filtrate was separated and the  
15 aqueous layer was extracted with Et<sub>2</sub>O. The organic layers were combined and  
washed with 15% NH<sub>4</sub>OH (x 2) and the aqueous layer was back extracted with  
Et<sub>2</sub>O. The combined organic phases were dried over Na<sub>2</sub>SO<sub>4</sub>, filtered, and  
concentrated to give 2.31 g of crude methyl 6-(trimethylstannyl)nicotinate

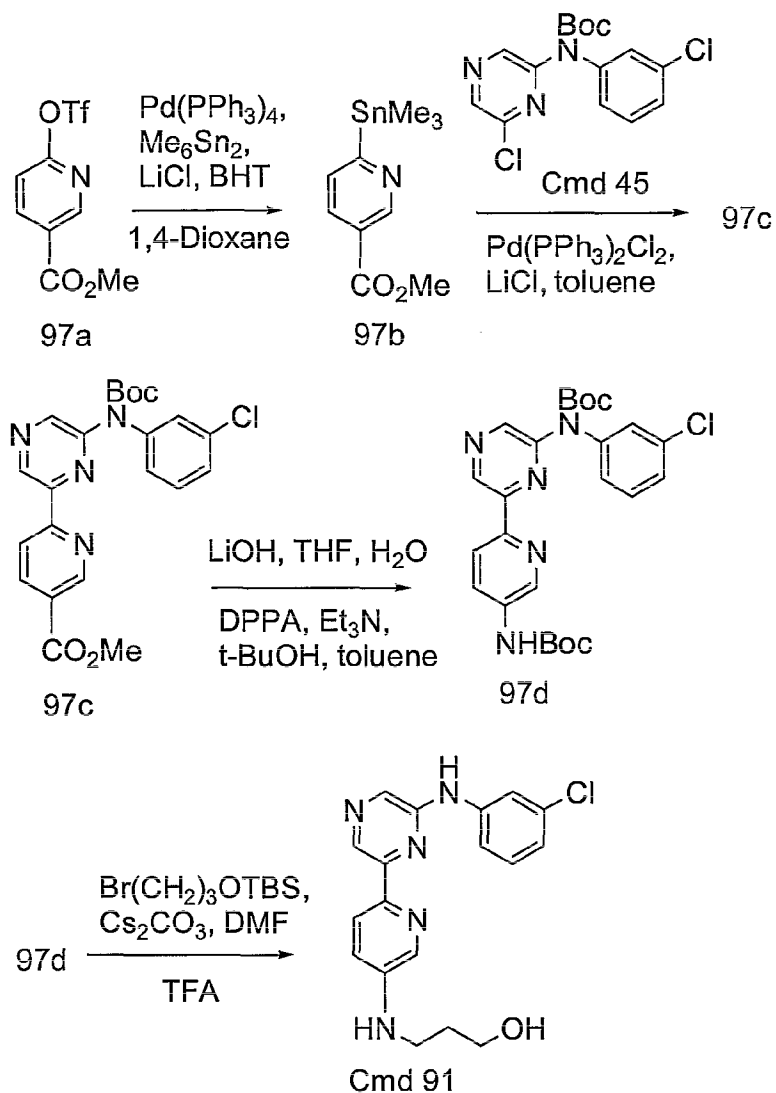
Compound **97b** as a brown oil.

*N*-(*tert*-butoxycarbonyl)-*N*-(3-chlorophenyl)-2-amino-6-chloropyrazine  
**Cmd 45** (2.20 g, 6.47 mmol), dichlorobis(triphenylphosphine) palladium (0.780  
5 g, 1.11 mmol), LiCl (0.900 g, 21.2 mmol) and anhydrous toluene (80 mL) were  
added to the crude Compound **97b**. The reaction mixture was heated at 100 °C  
for 1 h under nitrogen and then left at room temperature overnight. After  
filtration through Celite, the filtrate was concentrated and flash chromatographed  
(EtOAc/hexane as solvent) to give 1.19 g (38%, two steps) of Compound **97c** as  
10 a white solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.43 (s, 1 H), 9.24 (d, *J* = 2.1 Hz, 1  
H), 9.06 (s, 1 H), 8.31 (dd, *J* = 8.3, 2.1 Hz, 1 H), 7.93 (d, *J* = 8.3 Hz, 1 H), 7.39-  
7.31 (m, 3 H), 7.19-7.15 (m, 1 H), 3.97 (s, 3 H), 1.49 (s, 9 H); MS (ES) *m/z*: 463  
(*M*+Na<sup>+</sup>). Anal. Calcd. For C<sub>22</sub>H<sub>21</sub>N<sub>4</sub>O<sub>4</sub>Cl: C, 59.93; H, 4.80; N, 12.71. Found:  
C, 60.03; H, 4.67; N, 12.25.

15

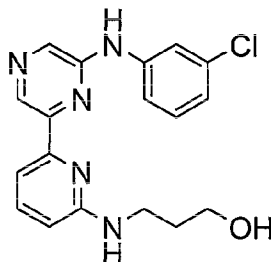
A mixture of Compound **97c** (540 mg, 1.22 mmol) and LiOH (44 mg, 1.8  
mmol) in THF (16 mL) and water (4 mL) was stirred for 1 h at room  
temperature. More LiOH (30 mg, 1.3 mmol) was added to the cloudy solution.  
After another 3 h at room temperature, the solution became clear. Acetic acid  
20 (0.30 mL) was added and the solution was concentrated to about half of the  
original volume. After the addition of water, some solid formed. The solid was  
collected through filtration, washed with water, and dried under vacuum  
overnight to give 522 mg (100%) of a carboxylic acid as a yellow solid; MS (ES)  
*m/z*: 425 (*M*-H<sup>+</sup>). A mixture of the carboxylic acid (522 mg, 1.22 mmol), DPPA  
25 (500 mg, 1.82 mmol), and triethylamine (0.340 mL, 2.44 mmol) in *t*-BuOH (9  
mL) and toluene (9 mL) was heated at 60 °C for 30 min, then the temperature  
was slowly increased to 80 °C for 2 h and 90 °C for 1 h. After concentration, the  
reaction mixture was purified by flash chromatography (EtOAc/hexane as  
solvent) to give 393 mg (65%) of Compound **97d** as a yellow solid; <sup>1</sup>H NMR  
30 (300 MHz, CDCl<sub>3</sub>) δ 9.31 (s, 1 H), 8.92 (s, 1 H), 8.45 (d, *J* = 2.4 Hz, 1 H), 8.03  
(brd, *J* = 8.5 Hz, 1 H), 7.84 (d, *J* = 8.6 Hz, 1 H), 7.37-7.29 (m, 3 H), 7.19-7.16  
(m, 1 H), 6.67 (s, 1 H), 1.54 (s, 9 H), 1.49 (s, 9 H); MS (ES) *m/z*: 520 (*M*+Na<sup>+</sup>).  
Anal. Calcd. For C<sub>25</sub>H<sub>28</sub>N<sub>5</sub>O<sub>4</sub>Cl: C, 60.30; H, 5.67; N, 14.06. Found: C, 60.16; H,  
5.61; N, 13.81.

A mixture of Compound **97d** (43 mg, 0.086 mmol), (3-bromopropoxy)-*tert*-butyldimethylsilane (30 mg, 0.12 mmol), and Cs<sub>2</sub>CO<sub>3</sub> (45 mg, 0.14 mmol) in dry DMF (1 mL) was heated at 65 °C for 2 h then 80 °C for 2.5 h. The reaction mixture was concentrated and purified by column chromatography (EtOAc/hexane as solvent) to give 51 mg (88%) of a *N*-akylated product as a clear oil. The *N*-akylated product (385 mg, 0.575 mmol) was dissolved in TFA (6 mL) and the solution was stirred at room temperature for 3 h before concentration. A saturated NH<sub>4</sub>OH solution was added to the residue until the mixture was made basic, followed by the addition of water. The precipitated solid was collected through filtration, washed with water and dried under vacuum. The product was purified by flash chromatography on silica gel (CH<sub>2</sub>Cl<sub>2</sub>/MeOH as solvent) to provide 176 mg (86%) of **Cmd 91** as a yellow solid; <sup>1</sup>H NMR (300 MHz, DMSO-*d*<sub>6</sub>) δ 9.70 (s, 1 H), 8.74 (s, 1 H), 8.11-8.08 (m, 3 H), 7.99 (d, *J* = 8.6 Hz, 1 H), 7.63 (d, *J* = 8.4 Hz, 1 H), 7.37 (t, *J* = 8.1 Hz, 1 H), 7.06 (dd, *J* = 8.6, 2.6 Hz, 1 H), 7.01 (d, *J* = 7.9 Hz, 1 H), 6.37 (m, 1 H), 4.52 (t, *J* = 5.0 Hz, 1 H), 3.53 (m, 2 H), 3.18 (m, 2 H), 1.74 (m, 2 H); MS (ES) *m/z*: 356 (M+H<sup>+</sup>). Anal. Calcd. For C<sub>18</sub>H<sub>18</sub>N<sub>5</sub>OCl.0.24 H<sub>2</sub>O: C, 60.03; H, 5.17; N, 19.45. Found: C, 60.45; H, 5.24; N, 19.03.



## EXAMPLE 98

## COMPOUND 92



5

A mixture of 2-amino-6-bromopyridine Compound **98a** (3.46 g, 20.0 mmol), di-*tert*-butyl dicarbonate (4.80 g, 22.0 mmol), and 4-(dimethylamino)pyridine (0.244 g, 2 mmol) in *t*-BuOH (50 mL) was stirred at room temperature for more than 24 h. The solution was concentrated and

purified by flash chromatography (EtOAc/hexane as solvent) to give 1.36 g (25%) of *N*-(*tert*-butoxycarbonyl)-2-amino-6-bromopyridine as clear crystals; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 7.88 (d, *J* = 8.2 Hz, 1 H), 7.50 (t, *J* = 8.0 Hz, 1 H), 7.22 (brs, 1 H), 7.12 (d, *J* = 7.7 Hz, 1 H), 1.51 (s, 9 H). (3-Bromopropoxy)-*tert*-butyldimethylsilane (1.50 g, 5.93 mmol) and Cs<sub>2</sub>CO<sub>3</sub> (2.43 g, 7.46 mmol) were added to the solution of crystals in dry DMF (20 mL). After stirring at 70 °C for 18 h, the solvent was evaporated under reduced pressure and the residue was purified by column chromatography (EtOAc/hexane) to provide 1.93 g (88%) of Compound **98b** as a clear oil; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 7.66 (d, *J* = 8.2 Hz, 1 H), 7.44 (m, 1 H), 7.15 (d, *J* = 7.6 Hz, 1 H), 3.99 (t, *J* = 7.3 Hz, 2 H), 3.67 (t, *J* = 6.4 Hz, 2 H), 1.86 (m, 2 H), 1.51 (s, 9 H), 0.88 (s, 9 H), 0.03 (s, 6 H); MS (ES) *m/z*: 467 (M+Na<sup>+</sup>). Anal. Calcd. For C<sub>19</sub>H<sub>33</sub>N<sub>2</sub>O<sub>3</sub>BrSi: C, 51.23; H, 7.47; N, 6.29. Found: C, 51.15; H, 7.80; N, 6.24. A mixture of Compound **98b** (150 mg, 0.337 mmol), bis(tributyltin) (0.340 mL, 0.673 mmol), tetrakis(triphenylphosphine)palladium (40 mg, 0.035 mmol), LiCl (43 mg, 1.0 mmol), and 2,6-di-*tert*-butyl-4-methylphenol (3 mg, 0.014 mmol) in anhydrous 1,4-dioxane (3 mL) was refluxed at 100 °C for 4 h under nitrogen. The solvent was removed under reduced pressure and the residue was chromatographed over silica gel (ethyl acetate/hexane as solvent) to give 152 mg (69%) of Compound **98c** as a clear oil; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 7.49 (d, *J* = 8.5 Hz, 1 H), 7.42 (m, 1 H), 7.08 (d, *J* = 7.7 Hz, 1 H), 4.03 (t, *J* = 7.3 Hz, 2 H), 3.65 (t, *J* = 6.6 Hz, 2 H), 1.88 (m, 2 H), 1.61-1.50 (m, 6 H), 1.52 (s, 9 H), 1.37-1.26 (m, 6 H), 1.10-1.05 (m, 6 H), 0.88 (t, *J* = 7.4 Hz, 9 H), 0.87 (s, 9 H), 0.02 (s, 6 H); MS (ES) *m/z*: 656 (M+H<sup>+</sup>).

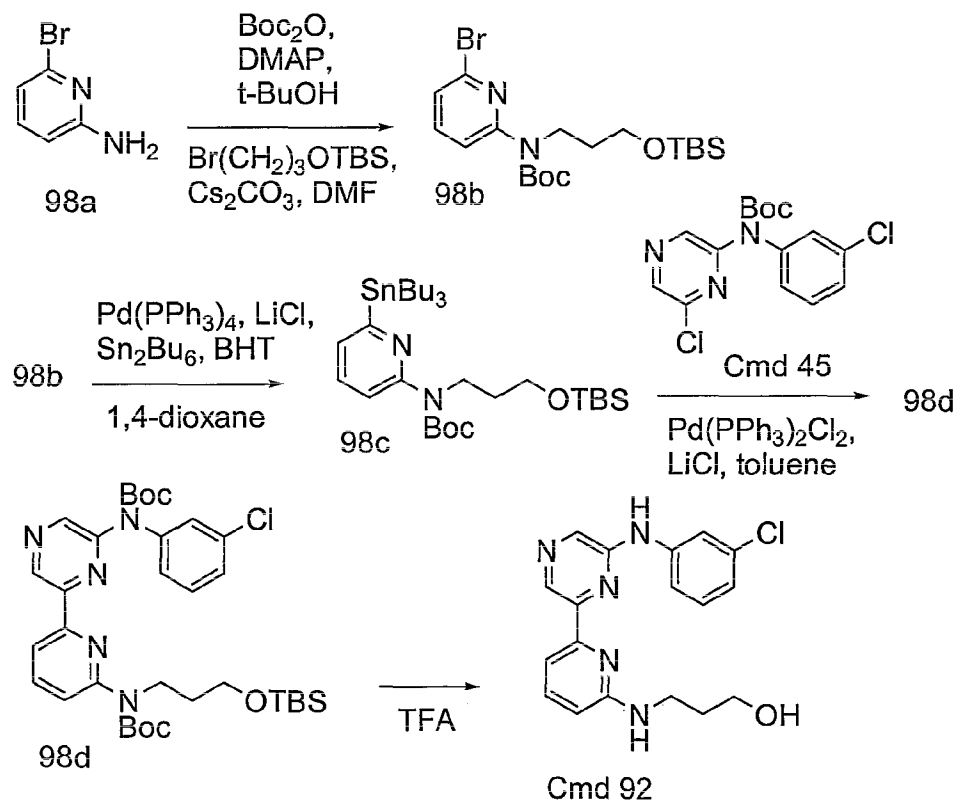
25

A mixture of Compound **98c** (103 mg, 0.157 mmol), *N*-(*tert*-butoxycarbonyl)-*N*-(3-chlorophenyl)-2-amino-6-chloropyrazine **Cmd 45** (61 mg, 0.18 mmol), dichlorobis(triphenylphosphine)palladium (13 mg, 0.018 mmol) and LiCl (23 mg, 0.54 mmol) in anhydrous toluene (3 mL) was stirred at 100 °C for 3 h under nitrogen. The cooled reaction mixture was concentrated under vacuum and purified by flash chromatography (EtOAc/hexane as solvent) to give 63 mg (62%) of Compound **98d** as a yellow oil; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.29 (s, 1 H), 8.93 (s, 1 H), 7.73 (dd, *J* = 7.8, 1.3 Hz, 1 H), 7.65 (m, 1 H), 7.61-7.58 (m, 1 H), 7.37-7.28 (m, 3 H), 7.19-7.15 (m, 1 H), 4.12 (t, *J* = 7.4 Hz, 2 H), 3.71 (t, *J* =

30

6.2 Hz, 2 H), 2.01-1.92 (m, 2 H), 1.53 (s, 9 H), 1.49 (s, 9 H), 0.85 (s, 9 H), 0.02 (s, 6 H); MS (ES)  $m/z$ : 692 ( $M+Na^+$ ). Anal. Calcd. For  $C_{34}H_{48}N_5O_5ClSi$ : C, 60.92; H, 7.22; N, 10.45. Found: C, 60.82; H, 7.10; N, 10.18.

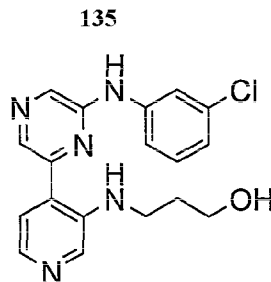
Compound **98d** (53 mg, 0.079 mmol) was dissolved in TFA (1.5 mL) and the solution was stirred at room temperature for 2 h before concentration. A saturated  $NH_4OH$  solution was added to the residue until the mixture was made basic followed by the addition of water. The precipitated solid was collected through filtration, washed with water and  $Et_2O$ , and dried under vacuum to provide 28 mg (100%) of **Cmd 92** 15 as a yellow solid;  $^1H$  NMR (300 MHz, DMSO- $d_6$ )  $\delta$  9.80 (s, 1 H), 8.85 (s, 1 H), 8.24 (s, 1 H), 8.12 (s, 1 H), 7.64 (d,  $J=8.1$  Hz, 1 H), 7.56 (m, 1 H), 7.40-7.35 (m, 2 H), 7.02 (d,  $J=7.7$  Hz, 1 H), 6.71 (brs, 1 H), 6.57 (d,  $J=8.3$  Hz, 1 H), 4.48 (brs, 1 H), 3.53 (t,  $J=6.3$  Hz, 2 H), 3.40 (m, 2 H), 1.76 (m, 2 H); MS (ES)  $m/z$ : 356 ( $M+H^+$ ). Anal. Calcd. For  $C_{18}H_{18}N_5OCl \cdot 0.55 H_2O$ : C, 59.11; H, 5.26; N, 19.15. Found: C, 59.46; H, 4.99; N, 18.78.



## EXAMPLE 99

## COMPOUND 93



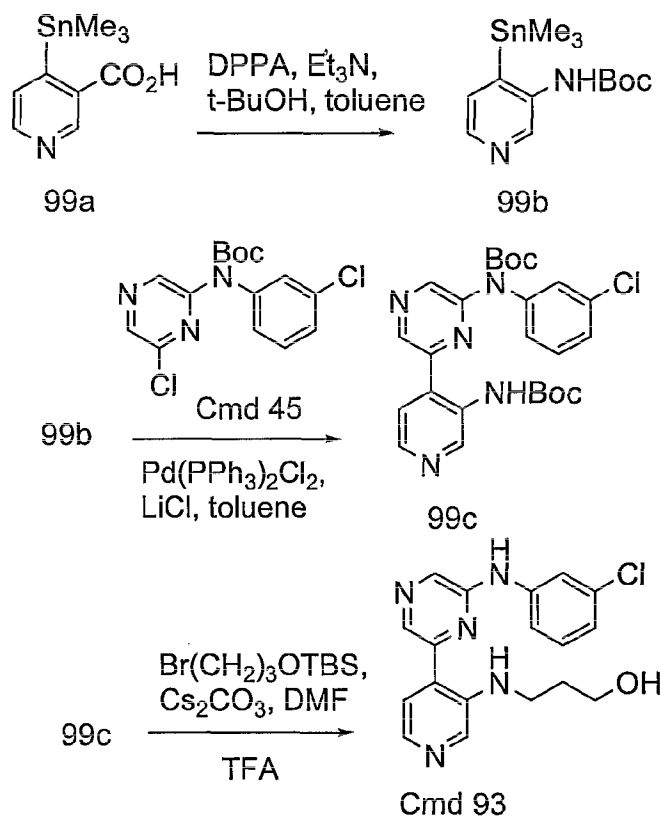


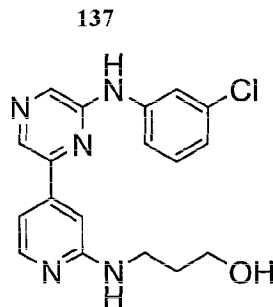
3-[[4-[6-[(3-chlorophenyl)amino]pyrazinyl]-  
3-pyridinyl]amino]-1-propanol (Cmd 93)

A mixture of 4-(trimethylstannyl)nicotinic acid Compound **99a** (300 mg, 1.05 mmol; Kelly, T. R. *J. Org. Chem.* **1992**, 57, 1593), DPPA (433 mg, 1.57 mmol), and triethylamine (0.250 mL, 1.79 mmol) in *t*-BuOH (2 mL) and toluene (2 mL) was heated at 60 °C for 1.5 h, then 90 °C for 3.5 h. After concentration, the reaction mixture was purified by flash chromatography (EtOAc/hexane as solvent) to give 213 mg (57%) of Compound **99b** as a white solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.54 (s, 1 H), 8.31 (d, *J* = 4.5 Hz, 1 H), 7.34 (d, *J* = 4.5 Hz, 1 H), 6.30 (brs, 1 H), 1.51 (s, 9 H), 0.37 (s, 9 H). Anal. Calcd. For C<sub>13</sub>H<sub>22</sub>N<sub>2</sub>O<sub>2</sub>Sn: C, 43.73; H, 6.21; N, 7.85. Found: 43.53; H, 6.12; N, 7.76. A mixture of Compound **99b** (162 mg, 0.454 mmol), *N*-(*tert*-butoxycarbonyl)-*N*-(3-chlorophenyl)-2-amino-6-chloropyrazine **Cmd 45** (155 mg, 0.454 mmol), dichlorobis(triphenylphosphine)palladium (64 mg, 0.091 mmol) and LiCl (60 mg, 1.42 mmol) in anhydrous toluene (10 mL) was stirred at 100 °C for 4 h under nitrogen. The reaction mixture was concentrated and purified by flash chromatography (EtOAc/hexane as solvent) to give 156 mg (69%) of Compound **99c** as a white solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.37 (s, 1 H), 9.23 (s, 1 H), 9.05 (s, 1 H), 8.71 (s, 1 H), 8.37 (d, *J* = 5.1 Hz, 1 H), 7.47-7.27 (m, 3 H), 7.20 (dd, *J* = 7.0, 2.0 Hz, 1 H), 1.56 (s, 9 H), 1.48 (s, 9 H); MS (ES) *m/z*: 498 (M+H<sup>+</sup>).

A mixture of Compound **99c** (29 mg, 0.058 mmol), (3-bromopropoxy)-*tert*-butyldimethylsilane (22 mg, 0.087 mmol), and Cs<sub>2</sub>CO<sub>3</sub> (38 mg, 0.12 mmol) in dry DMF (1 mL) was heated at 70 °C for 2 h. The reaction mixture was concentrated and purified by column chromatography (EtOAc/hexane as solvent) to give 32 mg (82%) of a *N*-akylated product Compound **99d** as a yellow oil; MS (ES) *m/z*: 670 (M+H<sup>+</sup>). Anal. Calcd. For C<sub>34</sub>H<sub>48</sub>N<sub>5</sub>O<sub>5</sub>ClSi: C, 60.92; H, 7.22; N, 10.45. Found: C, 60.49; H, 7.18; N, 10.30. The *N*-akylated product Compound

**99d** (60 mg, 0.089 mmol) was dissolved in TFA (2 mL) and the solution was stirred at room temperature for 1.5 h before concentration. A saturated  $\text{NH}_4\text{OH}$  solution was added to the residue until the mixture was made basic followed by the addition of water. The precipitated solid was collected through filtration, washed with water and dried under vacuum. The product was purified by flash chromatography on silica gel ( $\text{CH}_2\text{Cl}_2/\text{MeOH}$  as solvent) to provide 28 mg (88%) of **Cmd 93** as a yellow solid;  $^1\text{H}$  NMR (300 MHz,  $\text{DMSO}-d_6$ )  $\delta$  9.90 (s, 1 H), 8.51 (s, 1 H), 8.28 (s, 1 H), 8.22 (s, 1 H), 7.95 (brd,  $J = 4.4$  Hz, 1 H), 7.83 (s, 1 H), 7.58 (d,  $J = 4.8$  Hz, 1 H), 7.51 (d,  $J = 8.5$  Hz, 1 H), 7.41 (t,  $J = 8.0$  Hz, 1 H), 7.11 (m, 2 H), 4.48 (m, 1 H), 3.37 (m, 2 H), 3.29 (m, 2 H), 1.08 (m, 2 H); MS (ES)  $m/z$ : 356 ( $\text{M}+\text{H}^+$ ). Anal. Calcd. For  $\text{C}_{18}\text{H}_{18}\text{N}_5\text{OCl}\cdot 0.6 \text{H}_2\text{O}$ : C, 58.97; H, 5.28; N, 19.10. Found: C, 58.94; H, 5.53; N, 19.10.

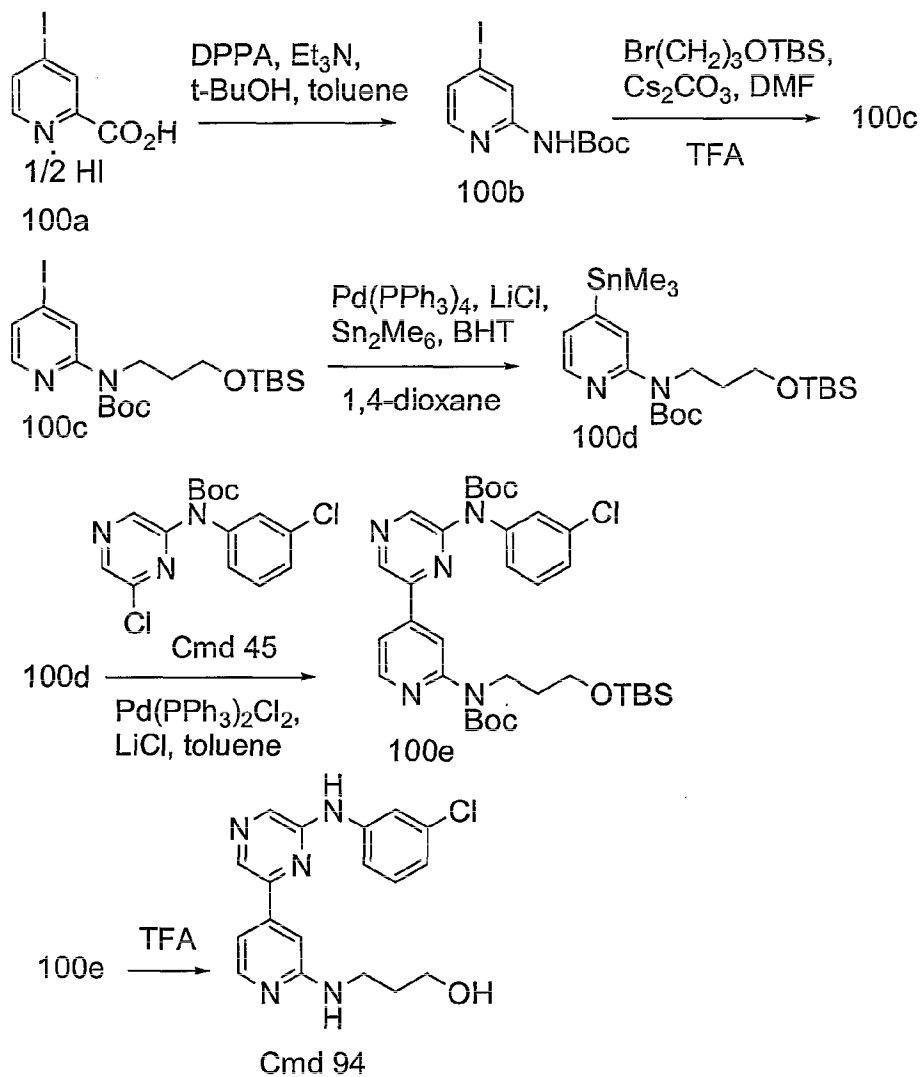




A mixture of 4-iodopicolinic acid Compound **100a** (1.00 g, 3.30 mmol; Lohse, O. *Synth. Commun.* 1996, 26, 2017), DPPA (1.36 g, 4.95 mmol), and triethylamine (1.4 mL, 10 mmol) in *t*-BuOH (5.5 mL) and toluene (5 mL) was heated at 65 °C for 1.5 h, then 100 °C for 4 h. After concentration, the reaction mixture was purified by flash chromatography (EtOAc/hexane as solvent) to give 515 mg (50%) of Compound **100b** as a white solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.17 (brs, 1 H), 8.48 (s, 1 H), 7.98 (dd, *J* = 5.2, 1.5 Hz, 1 H), 7.34 (dd, *J* = 5.2, 1.3 Hz, 1 H), 1.56 (s, 9 H). MS (ES) *m/z*: 343 (M+Na<sup>+</sup>). A mixture of Compound **100b** (330 mg, 1.03 mmol), (3-bromopropoxy)-*tert*-butyldimethylsilane (340 mg, 1.34 mmol), and Cs<sub>2</sub>CO<sub>3</sub> (504 mg, 1.55 mmol) in dry DMF (4 mL) was stirred at 70 °C for 3 h. The solvent was evaporated under reduced pressure and the residue was purified by column chromatography (EtOAc/hexane) to provide 450 mg (89%) of Compound **100c** as a clear oil; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 8.11 (s, 1 H), 8.00 (d, *J* = 5.2 Hz, 1 H), 7.33 (dd, *J* = 5.2, 1.3 Hz, 1 H), 3.99 (t, *J* = 7.3 Hz, 2 H), 3.65 (t, *J* = 6.3 Hz, 2 H), 1.84 (m, 2 H), 1.52 (s, 9 H), 0.87 (s, 9 H), 0.02 (s, 6 H); MS (ES) *m/z*: 515 (M+Na<sup>+</sup>).

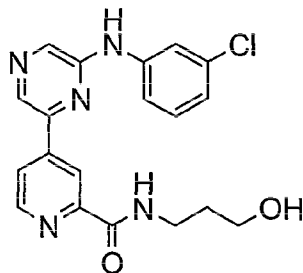
A mixture of Compound **100c** (650 mg, 1.32 mmol), bis(trimethyltin) (870 mg, 2.66 mmol), tetrakis(triphenylphosphine)palladium (150 mg, 0.130 mmol), LiCl (170 mg, 4.00 mmol), and 2,6-di-*tert*-butyl-4-methylphenol (12 mg, 0.054 mmol) in anhydrous 1,4-dioxane (12 mL) was heated at 90 °C for 1.5 h under nitrogen. The solvent was removed under reduced pressure and the residue was chromatographed over silica gel (EtOAc/hexane as solvent) to give 590 mg (84%) of Compound **100d** as a clear oil; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.09 (d, *J* = 4.7 Hz, 1 H), 7.56 (s, 1 H), 7.10 (d, *J* = 4.7 Hz, 1 H), 3.97 (t, *J* = 7.2 Hz, 2 H), 3.64 (t, *J* = 6.5 Hz, 2 H), 1.85 (m, 2 H), 1.49 (s, 9 H), 0.86 (s, 9 H), 0.33 (s, 9 H), 0.00 (s, 6 H); MS (ES) *m/z*: 527 (M-H<sup>+</sup>). Anal. Calcd. For C<sub>22</sub>H<sub>42</sub>N<sub>2</sub>O<sub>3</sub>SiSn: C, 49.92; H, 8.00; N, 5.29. Found: C, 50.32; H, 7.88; N, 5.20.

A mixture of Compound **100d** (550 mg, 1.04 mmol), *N*-(*tert*-butoxycarbonyl)-*N*-(3-chlorophenyl)-2-amino-6-chloropyrazine **Cmd 45** (360 mg, 1.06 mmol), dichlorobis(triphenylphosphine)palladium (73 mg, 0.104 mmol) and LiCl (132 mg, 3.11 mmol) in anhydrous toluene (20 mL) was stirred at 90 °C for 1 h then 100 °C for 2 h under nitrogen. The cooled reaction mixture was concentrated under vacuum and purified by flash chromatography (EtOAc/hexane as solvent) to give 380 mg (55%) of Compound **100e** as a yellow oil; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.00 (s, 1 H), 8.82 (s, 1 H), 8.40 (d, *J* = 5.2 Hz, 1 H), 8.04 (s, 1 H), 7.37-7.28 (m, 4 H), 7.16 (brd, *J* = 7.3 Hz, 1 H), 4.02 (m, 2 H), 3.65 (t, *J* = 6.3 Hz, 2 H), 1.85 (m, 2 H), 1.50 (s, 9 H), 1.49 (s, 9 H), 0.85 (s, 9 H), 0.00 (s, 6 H); MS (ES) *m/z*: 670 (M+H<sup>+</sup>). Anal. Calcd. For C<sub>34</sub>H<sub>48</sub>N<sub>5</sub>O<sub>5</sub>ClSi.0.3 H<sub>2</sub>O: C, 60.43; H, 7.25; N, 10.36. Found: C, 60.22; H, 7.04; N, 10.15. A solution of Compound **100e** (350 mg, 0.522 mmol) and TFA (4 mL) was left at room temperature overnight before concentration. A saturated NH<sub>4</sub>OH solution was added to the residue until the mixture was made basic followed by the addition of water. The precipitated solid was collected through filtration, washed with water, dried under vacuum, and purified by flash chromatography (CH<sub>2</sub>Cl<sub>2</sub>/MeOH as solvent) to provide 143 mg (77%) of **Cmd 94** as a yellow solid; <sup>1</sup>H NMR (300 MHz, DMSO-*d*<sub>6</sub>) δ 9.88 (s, 1 H), 8.54 (s, 1 H), 8.27 (s, 1 H), 8.10 (d, *J* = 5.8 Hz, 1 H), 8.00 (s, 1 H), 7.73 (d, *J* = 8.2 Hz, 1 H), 7.39 (t, *J* = 8.1 Hz, 1 H), 7.10 (s, 2 H), 7.04 (dd, *J* = 7.9, 1.0 Hz, 1 H), 6.69 (brt, *J* = 5.3 Hz, 1 H), 4.55 (brs, 1 H), 3.51 (t, *J* = 6.2 Hz, 2 H), 3.36 (m, 2 H), 1.73 (m, 2 H); MS (ES) *m/z*: 356 (M+H<sup>+</sup>). Anal. Calcd. For C<sub>18</sub>H<sub>18</sub>N<sub>5</sub>OCl.0.3 H<sub>2</sub>O: C, 59.85; H, 5.19; N, 19.39. Found: C, 60.03; H, 5.08; N, 19.20.



## EXAMPLE 101

## COMPOUND 95



5

3-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-  
2-thiazolyl]amino]-1-propanol (Cmd 95)

A mixture of methyl 4-iodopyridine Compound **101a** (0.800 g, 3.04 mmol; Lohse, O. *Synth. Commun.* 1996, 26, 2017), bis(trimethyltin) (1.70 g,

5.19 mmol), tetrakis(triphenylphosphine)palladium (350 mg, 0.303 mmol), LiCl (0.390 g, 9.19 mmol), and 2,6-di-*tert*-butyl-4-methylphenol (27 mg, 0.12 mmol) in anhydrous 1,4-dioxane (20 mL) was refluxed at 100 °C for 1 h under nitrogen. The solvent was removed under reduced pressure and the residue was

5 chromatographed over silica gel (EtOAc/hexane as solvent) to give 404 mg (44%) of methyl 4-trimethylstannylpicolinate Compound **101b** as a yellow oil; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 8.64 (d, *J* = 4.6 Hz, 1 H), 8.25 (s, 1 H), 7.59 (d, *J* = 4.5 Hz, 1 H), 4.01 (s, 3 H), 0.38 (s, 9 H); MS (ES) *m/z*: 324 (M+Na<sup>+</sup>). Anal. Calcd. For C<sub>10</sub>H<sub>15</sub>NO<sub>2</sub>Sn: C, 40.04; H, 5.04; N, 4.67. Found: C, 40.17; H, 4.63; N, 4.60. A mixture of methyl 4-trimethylstannylpicolinate Compound **101b** (350 mg, 1.17 mmol), *N*-(*tert*-butoxycarbonyl)-*N*-(3-chlorophenyl)-2-amino-6-chloropyrazine **Cmd 45** (400 mg, 1.18 mmol),

10 dichlorobis(triphenylphosphine)palladium (82 mg, 0.12 mmol) and LiCl (150 mg, 3.54 mmol) in anhydrous toluene (15 mL) was stirred at 100 °C for 4 h

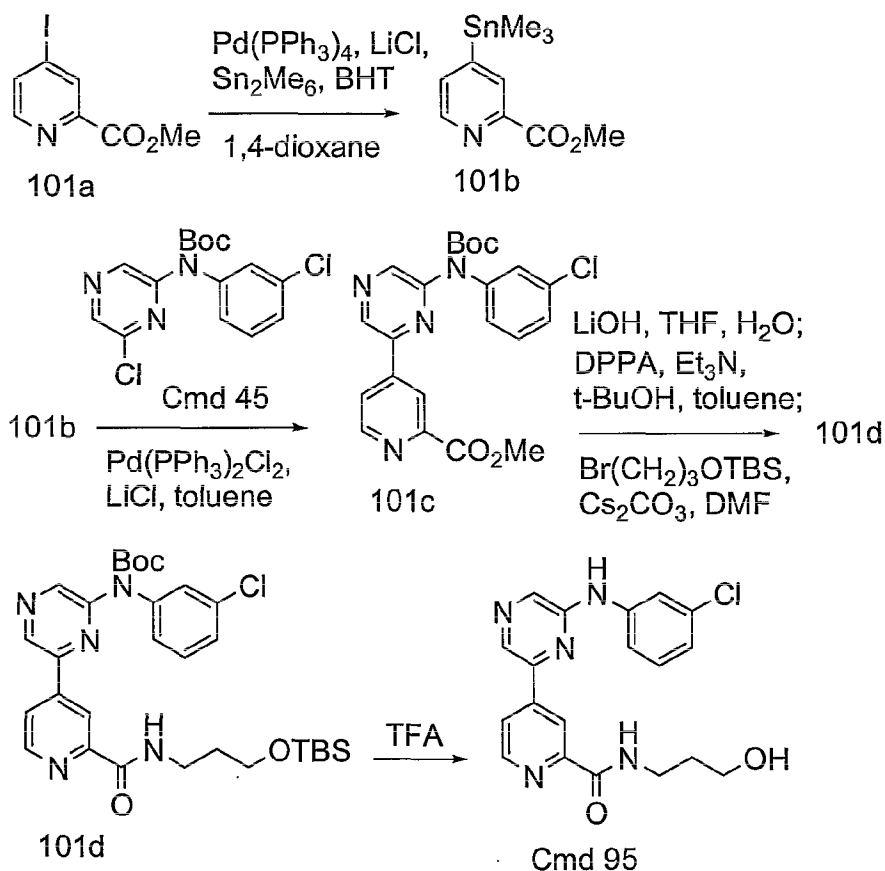
15 under nitrogen. The cooled reaction mixture was concentrated under vacuum and purified by flash chromatography (EtOAc/hexane as solvent) to give 260 mg (51%) of Compound **101c** as a yellow solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.17 (s, 1 H), 8.90 (s, 1 H), 8.80 (d, *J* = 4.9 Hz, 1 H), 8.52 (s, 1 H), 7.82 (dd, *J* = 5.0, 1.6 Hz, 1 H), 7.40-7.38 (m, 2 H), 7.30 (s, 1 H), 7.18 (brd, *J* = 6.8 Hz, 1 H), 4.04

20 (s, 3 H), 1.50 (s, 9 H); MS (ES) *m/z*: 441 (M+H<sup>+</sup>). Anal. Calcd. For C<sub>22</sub>H<sub>21</sub>N<sub>4</sub>O<sub>4</sub>Cl·0.25 H<sub>2</sub>O: C, 59.33; H, 4.87; N, 12.58. Found: C, 59.14; H, 4.60; N, 12.48.

Compound **101c** (260 mg, 0.590 mmol) was treated with LiOH (30 mg, 25 1.25 mmol) in THF (8 mL) and water (2 mL) for 40 min at room temperature. Acetic acid (10 drops) was added and the solution was concentrated to about half of the original volume. After the addition of water, some solid formed. The solid was collected through filtration, washed with water, and dried under vacuum overnight to give 235 mg (93%) of a carboxylic acid product as a yellow

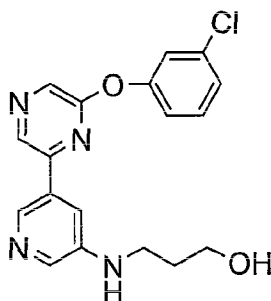
30 solid; MS (ES) *m/z*: 427 (M+H<sup>+</sup>). A mixture of the carboxylic acid product (220 mg, 0.515 mmol), DPPA (213 mg, 0.775 mmol), and triethylamine (0.150 mL, 1.08 mmol) in *t*-BuOH (4 mL) and toluene (4 mL) was heated at 65 °C for 1 h, then the temperature was slowly increased to 80 °C for 1 h and 100 °C for 1 h. After removal of solvents, the reaction mixture was purified by flash

chromatography (EtOAc/hexane as solvent) to give 140 mg of an amide (containing impurities) as a white solid. (3-Bromopropoxy)-*tert*-butyldimethylsilane (100 mg, 0.395 mmol), Cs<sub>2</sub>CO<sub>3</sub> (180 mg, 0.552 mmol) and DMF (4 mL) were added to the amide. After stirring at 70 °C for 17 h, the reaction mixture was concentrated and purified by column chromatography (EtOAc/hexane as solvent) to give 27 mg (8%, 3 steps) of Compound **101d** as a yellow solid; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 9.08 (s, 1 H), 8.94 (s, 1 H), 8.62 (d, *J* = 1.0 Hz, 1 H), 8.56 (d, *J* = 5.0 Hz, 1 H), 8.44 (brt, *J* = 5.4 Hz, 1 H), 7.73 (dd, *J* = 5.0, 1.7 Hz, 1 H), 7.40-7.33 (m, 2 H), 7.29 (t, *J* = 1.8 Hz, 1 H), 7.18 (dt, *J* = 7.6, 1.6 Hz, 1 H), 3.80 (t, *J* = 5.6 Hz, 2 H), 3.62 (m, 2 H), 1.86 (m, 2 H), 1.49 (s, 9 H), 0.92 (s, 9 H), 0.10 (s, 6 H); MS (ES) *m/z*: 669 (M-H<sup>+</sup>). A solution of Compound **101d** (27 mg, 0.047 mmol) and TFA (1 mL) was left at room temperature overnight before concentration. A saturated NH<sub>4</sub>OH solution was added to the residue until the mixture was made basic followed by the addition of water. The precipitated solid was filtered, washed with water, dried under vacuum, and purified by flash chromatography (CH<sub>2</sub>Cl<sub>2</sub>/MeOH as solvent) to provide 13 mg (72%) of **Cmd 95** as a yellow solid; <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>) δ 9.98 (s, 1 H), 8.90 (brt, *J* = 5.4 Hz, 1 H), 8.80 (s, 2 H), 8.68 (s, 1 H), 8.35 (s, 1 H), 8.24 (d, *J* = 4.7 Hz, 1 H), 8.02 (s, 1 H), 7.70 (d, *J* = 7.8 Hz, 1 H), 7.39 (t, *J* = 8.0 Hz, 1 H), 7.07 (d, *J* = 7.5 Hz, 1 H), 4.57 (t, *J* = 5.1 Hz, 1 H), 3.50 (m, 2 H), 3.41 (m, 2 H), 1.72 (t, *J* = 6.4 Hz, 2 H); MS (ES) *m/z*: 384 (M+H<sup>+</sup>).



## EXAMPLE 102

## COMPOUND 96



5

A mixture of **Cmd 1D** (450 mg, 1.71 mmol), 3-chlorophenol (330 mg, 2.56 mmol),  $\text{Pd}_2(\text{dba})_3$  (44.2 mg, 0.042 mmol), DPPF (75.6 mg, 0.134 mmol),  $\text{Cs}_2\text{CO}_3$  (1.11 g, 3.41 mmol) in anhydrous dioxane (5 mL) was stirred at reflux for 18 h under nitrogen. The reaction mixture was filtered thru celite and the filter cake was washed with dichloromethane. The filtrate was concentrated under vacuum. The residue was purified by column chromatography (EtOAc/hexane as solvent) and recrystallized from ethyl acetate/hexane to give 168 mg (27%) of Compound **102a** as a solid;  $^1\text{H NMR}$  (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.26



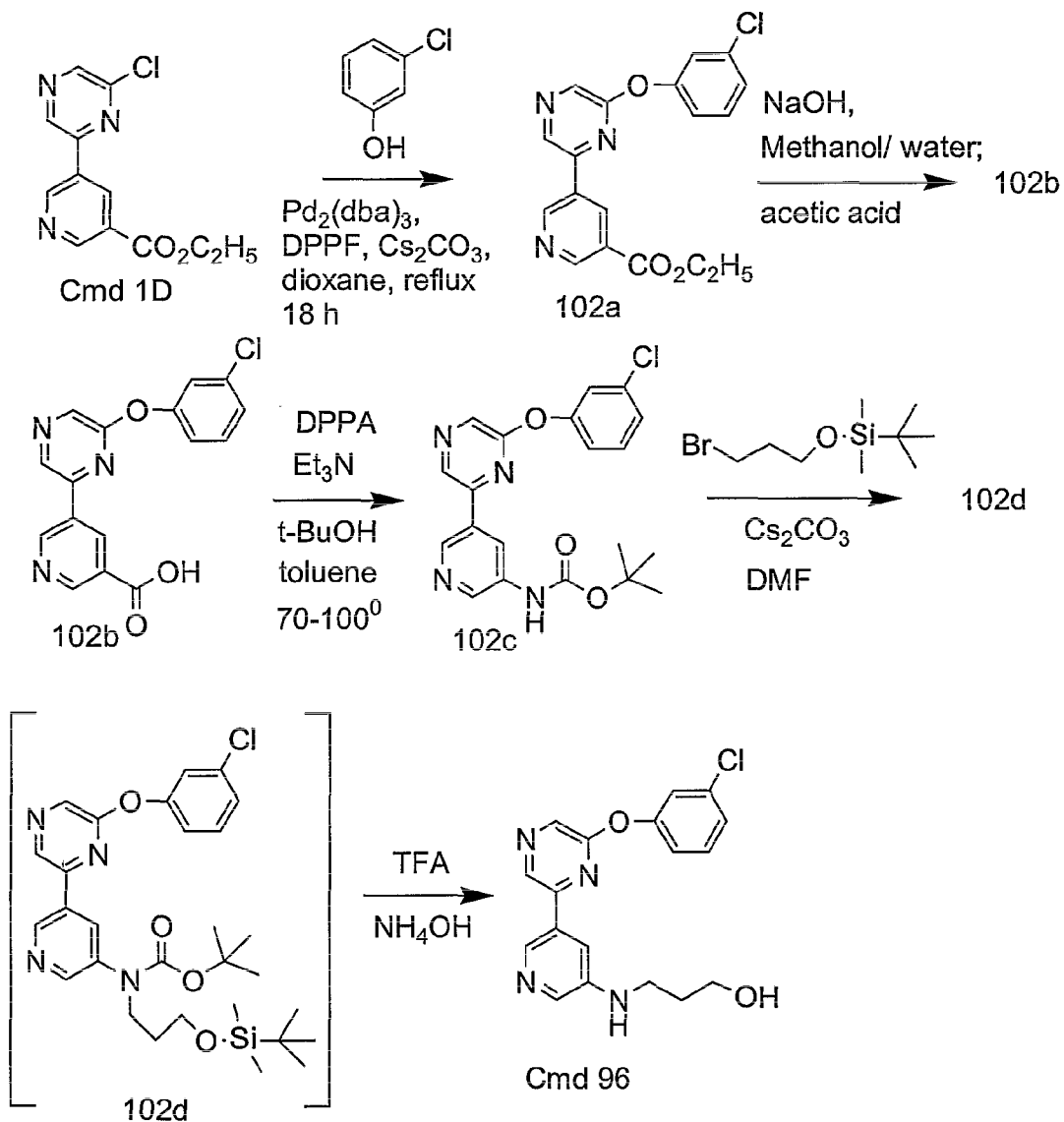
(brs, 2 H), 8.85 (s, 1 H), 8.73 (t,  $J = 2.1$  Hz, 1 H), 8.46 (s, 1 H), 7.39 (t,  $J = 8.4$  Hz, 1 H), 7.30-7.25 (m, 2 H), 7.16 (brd,  $J = 8.2$  Hz, 1 H), 4.44 (q,  $J = 7.1$  Hz, 2 H), 1.43 (t,  $J = 7.1$  Hz, 3 H); Anal. Calcd. For  $C_{18}H_{14}ClN_3O_3$ : C, 60.77; H, 3.97; N, 11.81. Found: C, 60.67; H, 3.92; N, 11.64. A mixture of Compound **102a** (150 mg, 0.44 mmol) was dissolved in methanol (4.3 mL) and stirred for 10 min then cooled to 0 °C.  $NaOH_{(aq)}$  (1 N, 0.74 mL) was added slowly and the mixture was stirred at 0 °C for 10 min then stirred at 20 °C for another 18 h. Glacial acetic acid (0.7 mL) was added to the reaction mixture followed by the addition of water (2.2 mL). A solid was formed. The solid was collected thru filtration, and washed with water (5x), dried in vacuum oven overnight to give 122 mg (85%) of Compound **102b** as a solid;  $^1H$  NMR (300 MHz,  $CD_3OD$ )  $\delta$  9.23 (s, 1 H), 9.14 (s, 1 H), 9.00 (s, 1 H), 8.85 (t,  $J = 2.1$  Hz, 1 H), 8.50 (s, 1 H), 7.47 (t,  $J = 8.1$  Hz, 1 H), 7.39-7.23 (m, 3 H); MS (ES)  $m/z$ : 326 ( $M-H^+$ ); Anal. Calcd. For  $C_{16}H_{10}ClN_3O_3$ : C, 58.67; H, 3.08; N, 12.82. Found: C, 58.55; H, 3.01; N, 12.66.

15

A mixture of Compound **102b** (107.7 mg, 0.33 mmol), DPPA (108 mg, 0.39 mmol), triethylamine (66 mg, 0.65 mmol), *t*-BuOH (1.4 mL) in toluene (1 mL) was stirred under nitrogen at 70 °C for 0.5 h then heated at reflux for 4 h. The reaction mixture was concentrated under vacuum. The product was purified by column chromatography (EtOAc/hexane as solvent) and recrystallized from EtOAc/hexane to give 51 mg (40%) of Compound **102c** as a solid;  $^1H$  NMR (300 MHz,  $CDCl_3$ )  $\delta$  8.81 (s, 1 H), 8.78 (d,  $J = 1.9$  Hz, 1 H), 8.51 (d,  $J = 2.5$  Hz, 1 H), 8.44 (brs, 1 H), 8.40 (s, 1 H), 7.39 (t,  $J = 8.2$  Hz, 1 H), 7.27-7.24 (m, 1 H), 7.17 (d,  $J = 7.6$  Hz, 1 H), 6.57 (brs, 2 H), 1.54 (s, 9 H); FAB-HRMS ( $M+H^+$ ). Calcd. for  $C_{20}H_{19}ClN_4O_3$  399.1224, found 399.1241. A mixture of Compound **102c** (51 mg 0.128 mmol), (3-bromopropoxy)-*t*-butyl-dimethylsilane (48.6 mg, 0.192 mmol) and  $Cs_2CO_3$  (125 mg, 0.384 mmol) in DMF (1.5 mL) was stirred at 70 °C under nitrogen for 36 h. The reaction mixture was diluted with water, extracted with ether (3x), dried ( $Na_2SO_4$ ) and concentrated. The product was purified by column chromatography (EtOAc/hexane as solvent) to give 28.8 mg of the silylated-product as an oil. The silylated-product was dissolved in TFA (0.34 mL) and stirred at 20 °C for 18 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a yellow solid was formed. The yellow solid was collected thru filtration, washed

30

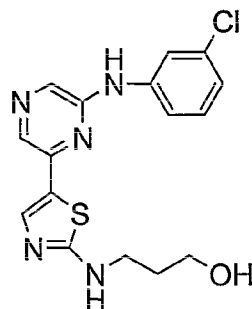
with water and dried under vacuum. The solid was recrystallized from  $\text{CH}_3\text{OH}/\text{EtOAc}$  to give 15 mg (33% two steps) of Compound **102d** as a solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CD}_3\text{OD}$ )  $\delta$  8.87 (s, 1 H), 8.4 (s, 1 H), 8.28 (s, 1 H), 7.96 (d,  $J=2.7$  Hz, 1 H), 7.49-7.21 (m, 5 H), 3.67 (t,  $J=6.3$  Hz, 2 H), 3.20 (t,  $J=6.9$  Hz, 2 H), 1.82 (m, 2 H); MS (ES)  $m/z$ : 357 ( $\text{M}+\text{H}^+$ ).



## EXAMPLE 103

## COMPOUND 97

145



A mixture of (2-amino-5-bromothiazole HBr) Compound **103a** (10 g, 38.4 mmol),  $\text{Boc}_2\text{O}$  (8.39 g, 38.4 mmol), DMAP (440 mg, 3.6 mmol) and  $\text{NaHCO}_3$  (9.6 g, 114 mmol) in *t*-BuOH (100 mL) was stirred at 20 °C for 16 h.

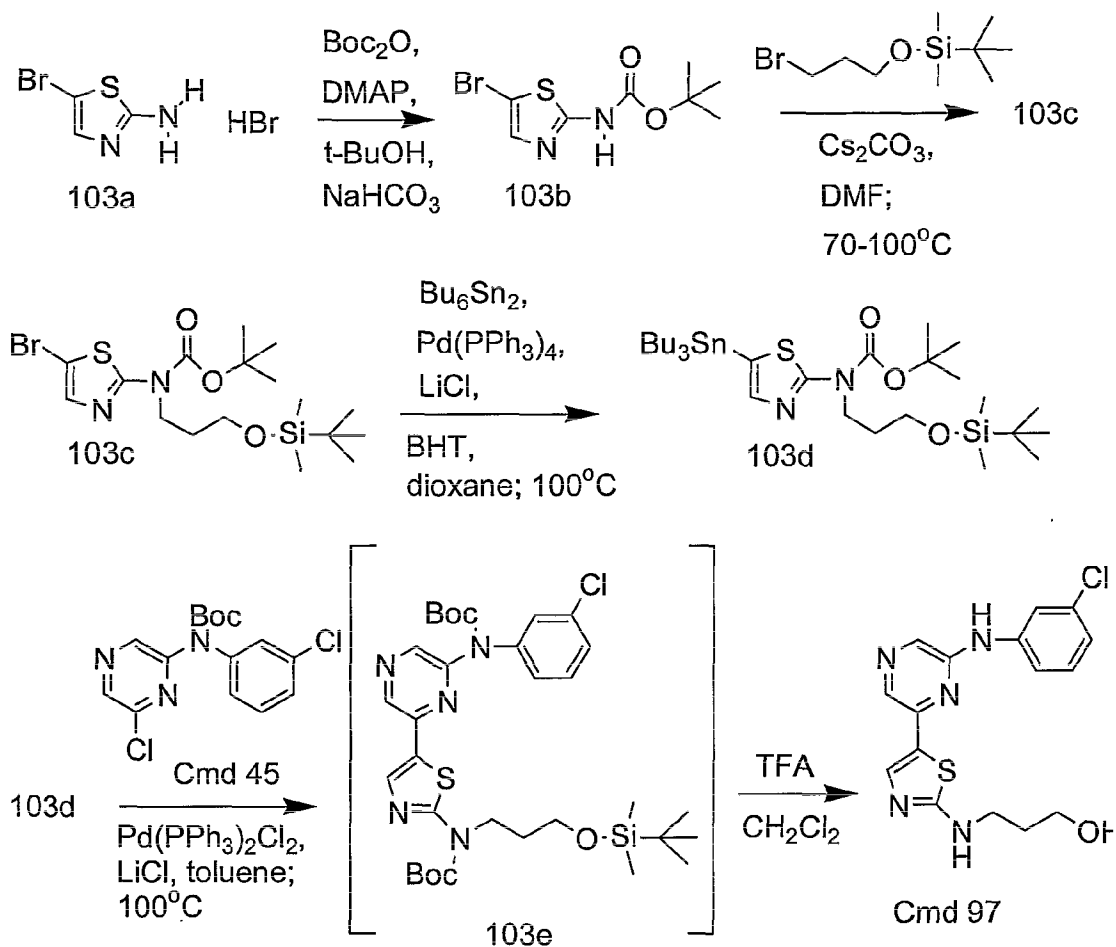
- 5 The reaction mixture was concentrated and the product was purified by column chromatography (EtOAc/hexane as solvent) and recrystallized from ethyl acetate/hexane to give 3.41 g (32%) of Compound **103b** as a white solid;  $^1\text{H}$  NMR (300 MHz,  $\text{D}^6$ -DMSO)  $\delta$  11.70 (brs, 1 H), 7.43 (s, 1 H), 1.48 (s, 9 H); Anal. Calcd. For  $\text{C}_8\text{H}_{11}\text{BrN}_2\text{O}_2\text{S}$ : C, 34.42; H, 3.97; N, 10.04. Found: C, 34.59; H, 3.95; N, 9.92. A mixture of Compound **103b** (2.2 g, 7.91 mmol), (3-bromopropoxy)-*t*-butyl-dimethylsilane (3.46 g, 12.7 mmol) and  $\text{Cs}_2\text{CO}_3$  (7.7 g, 23.7 mmol) in DMF (24 mL) was stirred at 70 °C under nitrogen for 18 h. The reaction mixture was diluted with water, extracted with ether (3x), dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated. The product was purified by column
- 15 chromatography (EtOAc/hexane as solvent) to give 2.6 g (72%) of the silylated-product Compound **103c** as an oil.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  7.22 (s, 1 H), 4.08 (t,  $J = 7.5$  Hz, 2 H), 3.65 (t,  $J = 6.3$  Hz, 2 H), 1.85 (m, 2 H), 1.53 (s, 9 H), 0.85 (s, 9 H), 0.01 (s, 6 H); Anal. Calcd. For  $\text{C}_{17}\text{H}_{31}\text{BrN}_2\text{O}_3\text{SSi}$ : C, 45.22; H, 6.92; N, 6.20. Found: C, 45.08; H, 6.72; N, 6.12.

20

- A mixture of Compound **103c** (152 mg, 0.337 mmol), bis(tributyltin) (390 mg, 0.34 mmol), tetrakis(triphenylphosphine) palladium (40 mg, 0.035 mmol), LiCl (43 mg, 1.0 mmol) and BHT (3 mg, 0.014 mmol) in dioxane (3 mL) was stirred at 100 °C for 4 h under nitrogen. The cooled reaction mixture was
- 25 concentrated under vacuum. The residue was purified by column chromatography (EtOAc/hexane as solvent) to give 56 mg (25%) of Compound **103d** as an oil;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  7.27 (s, 1 H), 4.15 (t,  $J = 7.4$  Hz, 2 H), 3.67 (t,  $J = 6.3$  Hz, 2 H), 1.87 (m, 2 H), 1.54-1.46 (m, 15 H), 1.28 (m, 6 H),

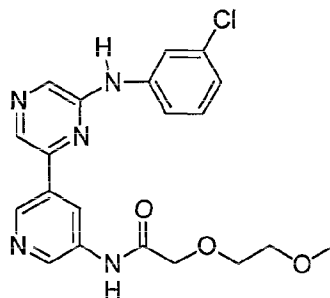
1.05 (t,  $J = 8.3$  Hz, 6 H), 0.85 (m, 18 H), 0.01 (s, 6 H); MS (ES)  $m/z$ : 663 ( $M+1^+$ ).

A mixture of Compound **103d** (140 mg, 0.21 mmol), **Cmd 45** (72 mg, 0.21 mmol),  $\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$  (15 mg, 0.021 mmol) and LiCl (27 mg, 0.62 mmol) in toluene (3.5 mL) was stirred at 100 °C for 3 h under nitrogen. The cooled reaction mixture was concentrated under vacuum. The residue was purified by column chromatography (EtOAc/hexane as solvent) to give 96 mg (68%) of the silylated-product Compound **103e** as an oil. The silylated-product Compound **103e** was dissolved in dichloromethane (2 mL) and TFA (2.6 mL) and stirred at 20 °C for 18 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a yellow solid was formed. The yellow solid was collected thru filtration, washed with water and dried under vacuum to give **Cmd 97** as a light yellow solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CD}_3\text{OD}$ )  $\delta$  8.23 (s, 1 H), 8.10 (t,  $J = 2.0$  Hz, 1 H), 7.84 (s, 1 H), 7.74 (s, 1 H), 7.45 (dd,  $J = 8.3, 1.3$  Hz, 1 H), 7.26 (t,  $J = 8.1$  Hz, 1 H), 6.97 (dd,  $J = 7.8, 1.1$  Hz, 1 H), 3.68 (t,  $J = 6.2$  Hz, 2 H), 3.46 (t,  $J = 6.9$  Hz, 2 H), 1.88 (m, 2 H); MS (ES)  $m/z$ : 362 ( $M+1^+$ ).



## EXAMPLE 104

## COMPOUND 98



5

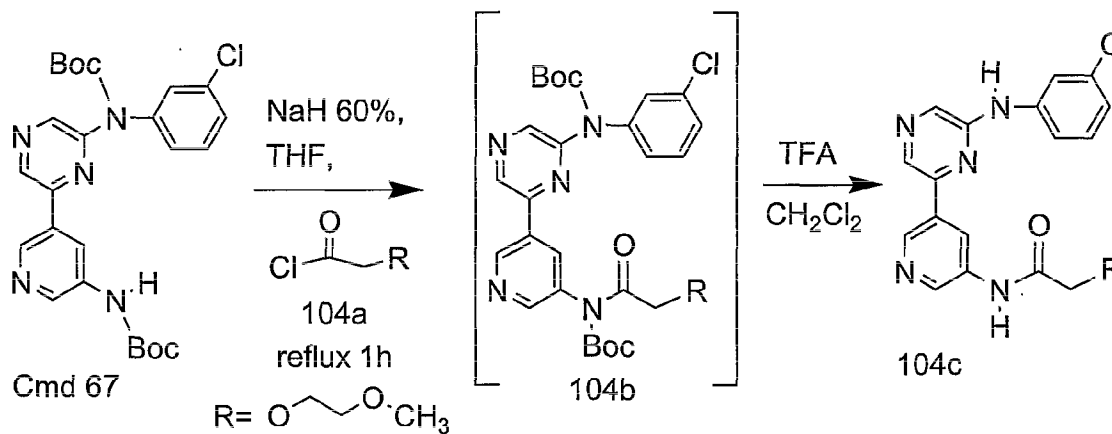
*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-

3-pyridinyl]-2-(2-methoxyethoxy)-acetamide (Cmd 98)

A mixture of **Cmd 67** (156 mg, 0.3 mmol) and 60% NaH (166 mg, 3.9 mmol), in THF (9 mL) was stirred under nitrogen at  $20^\circ\text{C}$  for 10 min then (2-

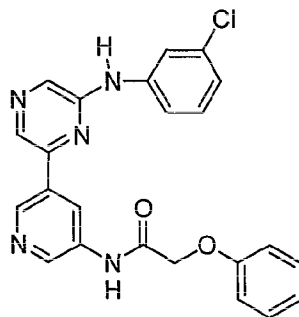
10 methoxyethoxy)acetyl chloride Compound **104a** (where  $\text{R} = \text{O}-\text{CH}_2-\text{CH}_2-\text{O}-\text{CH}_3$ ); (594 mg, 3.9 mmol) was added. The reaction was then stirred at reflux for 1 h.

Saturated  $\text{NaHCO}_3$  was added. The resulting THF layer was dried ( $\text{Na}_2\text{SO}_4$ ) then concentrated under vacuum and purified by column chromatography (EtOAc/hexane as solvent) to give 122 mg (89%) of the Boc-protected amide Compound **104b** as an oil. The Boc-protected amide Compound **104b** was stirred in TFA (1 mL) at 20 °C for 18 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11 and a yellow solid was formed. The solid was collected thru filtration, washed with water and dried under vacuum and purified by column chromatography (EtOAc/acetone as solvent) to give 20 mg (16%) of **Cmd 98** (Compound **104c**) where  $\text{R} = \text{O}-\text{CH}_2-\text{CH}_2-\text{O}-\text{CH}_3$ ; as an off-white solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CD}_3\text{OD}$ )  $\delta$  9.00 (d,  $J = 1.8$  Hz, 1 H), 8.88 (brs, 1 H), 8.85 (brs, 1 H), 8.49 (s, 1 H), 8.16 (s, 1 H), 7.91 (t,  $J = 2.0$  Hz, 1 H), 7.74 (dd,  $J = 8.2, 1.1$  Hz, 1H), 7.33 (t,  $J = 8.0$  Hz, 1 H), 7.00 (d,  $J = 7.6$  Hz, 1 H), 4.57 (brs, 1 H), 4.21 (s, 2 H), 3.80 (m, 2 H), 3.67 (m, 2 H), 3.43 (s, 3 H); Anal. Calcd. For  $\text{C}_{20}\text{H}_{20}\text{ClN}_5\text{O}_3 \cdot 0.3 \text{H}_2\text{O}$ : C, 57.29; H, 4.95; N, 16.70. Found: C, 57.33; H, 4.84; N, 16.51.

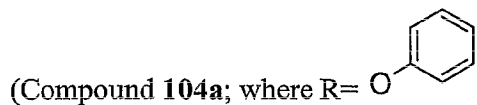


## EXAMPLE 105

## COMPOUND 99



Following the procedure of Example 104, a mixture of **Cmd 67** (156 mg, 0.3 mmol) and 60% NaH (90 mg, 2.1 mmol), in THF (9 mL) was stirred under nitrogen at 20 °C for 10 min then phenoxyacetyl chloride Compound **105a**



5 reaction was then stirred at reflux for 0.5 h. Aqueous NaHCO<sub>3</sub> was added then extracted with ether. The ether layer was dried (Na<sub>2</sub>SO<sub>4</sub>) then concentrated under vacuum and purified by column chromatography (EtOAc/hexane as solvent) to give 134 mg of the Boc-protected amide Compound **105b** as an oil. The Boc-protected amide Compound **105b** was stirred in TFA (1 mL) at 20 °C  
10 for 48 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11 and was then extracted with ethyl acetate. The ethyl acetate layer was dried on Na<sub>2</sub>SO<sub>4</sub> then concentrated under vacuum and purified by column chromatography (EtOAc/acetone as solvent) to give 30

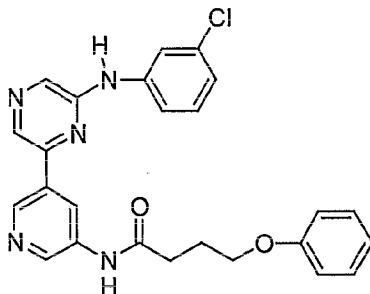


15 solid; <sup>1</sup>H NMR (300 MHz, D<sup>6</sup>-DMSO) δ 10.48 (s, 1H), 9.89 (s, 1 H), 9.00 (d, *J* = 1.6 Hz, 1 H), 8.86 (brs, 2 H), 8.62 (s, 1 H), 8.26 (s, 1 H), 7.87 (s, 1 H), 7.84 (s, 1 H), 7.34 (t, *J* = 7.6 Hz, 3 H), 7.07-6.97 (m, 4 H), 4.79 (s, 2 H); FAB-HRMS (M+H<sup>+</sup>). Calcd. for C<sub>23</sub>H<sub>18</sub>ClN<sub>5</sub>O<sub>2</sub> 432.1227, found 432.1238.

20

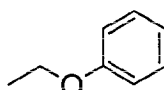
## EXAMPLE 106

## COMPOUND 100

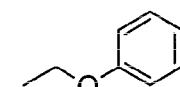


Following the procedure of Example 104, a mixture of **Cmd 67** (250 mg, 0.5 mmol) and 60% NaH (150 mg, 3.5 mmol), in THF (9 mL) was stirred under  
25 nitrogen at 20 °C for 10 min then 4-phenoxybutyryl chloride Compound **106a**

150

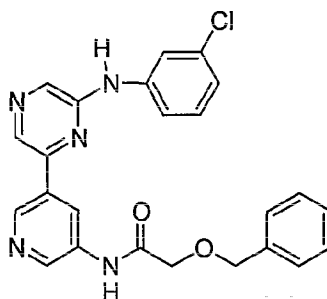
(Compound **104a**; where R= ) (580 mg, 2.9 mmol) was added.

The reaction was then stirred at reflux for 1 h. Aqueous NaHCO<sub>3</sub> was added then extracted with ether. The ether layer was dried on Na<sub>2</sub>SO<sub>4</sub> then concentrated under vacuum and purified by column chromatography (EtOAc/hexane as solvent) to give 188 mg of the Boc-protected amide Compound **106b**. The Boc-protected amide Compound **106b** was stirred in dichloromethane (3 mL) and TFA (1 mL) at 20 °C for 48 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11 and was then extracted with hot ethyl acetate. The ethyl acetate layer was dried (Na<sub>2</sub>SO<sub>4</sub>) then concentrated under vacuum and purified by recrystallization from ethyl acetate

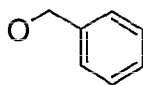
to give 30 mg (31%) of **Cmd 100** (Compound **104c**; where R= ) as an off-white solid; <sup>1</sup>H NMR (300 MHz, D<sup>6</sup>-DMSO) δ 10.36 (s, 1 H), 9.89 (s, 1 H), 8.95 (s, 1 H), 8.83 (s, 1 H), 8.76 (s, 1 H), 8.60 (s, 1 H), 8.26 (s, 1 H), 7.88-7.84 (m, 2 H), 7.38 (t, *J* = 8.1 Hz, 1 H), 7.31-7.25 (m, 2 H), 7.02 (d, *J* = 7.9 Hz, 1 H), 6.95-6.90 (m, 3 H), 4.05 (t, *J* = 6.3 Hz, 2 H), 2.59 (t, *J* = 7.3 Hz, 2 H), 2.08 (m, 2 H); FAB-HRMS (M+H<sup>+</sup>). Calcd. for C<sub>25</sub>H<sub>22</sub>ClN<sub>5</sub>O<sub>2</sub> 460.1540, found 460.1542.

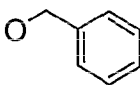
## EXAMPLE 107

## COMPOUND 101



Following the procedure of Example 104, a mixture of **Cmd 67** (250 mg, 0.5 mmol) and 60% NaH (150 mg, 3.5 mmol), in THF (9 mL) was stirred under nitrogen at 20 °C for 1 h then benzyloxycarbonyl chloride Compound **107a**

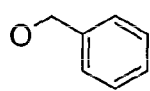


(Compound **104a**; where R= ) (646 mg, 3.5 mmol) was added. The



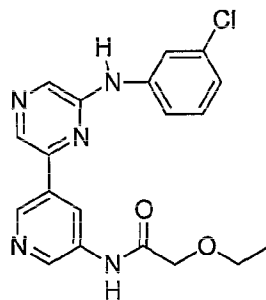
reaction was then stirred at reflux for 1 h. Saturated  $\text{NaHCO}_{3(\text{aq})}$  was added then extracted with ether. The ether layer was dried ( $\text{Na}_2\text{SO}_4$ ) then concentrated under vacuum and purified by column chromatography (EtOAc/hexane as solvent) to give 264 mg of the Boc-protected amide Compound **107b** as an oil.

- 5 The Boc-protected amide Compound **107b** was stirred in dichloromethane (4.2 mL) and TFA (1.4 mL) at 20 °C for 4 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11 and was then extracted with ethyl acetate. The ethyl acetate layer was dried ( $\text{Na}_2\text{SO}_4$ ) then concentrated under vacuum and purified by recrystallization from  
10 ethyl acetate to give 50 mg (22%) of **Cmd 101** (Compound **104a**; where R=



- (AD-12 as an off-white solid;  $^1\text{H}$  NMR (300 MHz,  $\text{D}^6$ -DMSO)  $\delta$  10.21 (s, 1 H), 9.89 (s, 1 H), 8.99 (d,  $J = 1.7$  Hz, 1 H), 8.86 (brs, 1 H), 8.61 (s, 1 H), 8.27 (s, 1 H), 7.90 (brs, 1 H), 7.86 (d,  $J = 8.1$  Hz, 1 H), 7.45-7.30 (m, 6 H), 7.03 (d,  $J = 9.4$  Hz, 1 H), 4.67 (s, 2 H), 4.18 (s, 2 H); Anal. Calcd. For  
15  $\text{C}_{24}\text{H}_{20}\text{ClN}_5\text{O}_2 \cdot 0.2 \text{H}_2\text{O}$ : C, 64.13; H, 4.57; N, 15.58. Found: C, 64.22; H, 4.45; N, 15.61.

#### EXAMPLE 108 COMPOUND 102

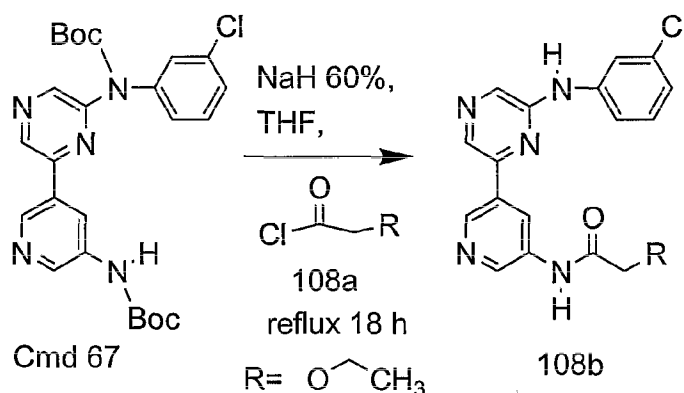


20

*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-  
3-pyridinyl]-2-ethoxy-acetamide (**Cmd 102**)

- A mixture of **Cmd 67** (250 mg, 0.5 mmol) and 60% NaH (150 mg, 3.5 mmol), in THF (6 mL) was stirred under nitrogen at 20 °C for 1 h then  
25 ethoxyacetyl chloride Compound **108a** (where R= ethoxyene) (427 mg, 3.5 mmol) in THF (3 mL) was added. The reaction was then stirred at reflux for 18 h. Water was added then extracted with ethyl acetate. The ether layer was dried ( $\text{Na}_2\text{SO}_4$ ) then concentrated under vacuum and purified by column

chromatography (EtOAc/hexane as solvent) to give 80 mg (42%) of **Cmd 102** (Compound **108b**; where R= ethoxyene) as an off-white solid; <sup>1</sup>H NMR (300 MHz, D<sup>6</sup>-DMSO) δ 10.08 (s, 1 H), 9.89 (s, 1 H), 8.99 (s, 1 H), 8.89 (s, 1 H), 8.82 (s, 1 H), 8.61 (s, 1 H), 8.27 (s, 1 H), 7.92 (d, *J* = 1.6 Hz, 1 H), 7.39 (t, *J* = 8.0 Hz, 1 H), 7.04 (d, *J* = 7.9 Hz, 1 H), 4.11 (s, 2 H), 3.62 (q, *J* = 7.0 Hz, 2 H), 1.22 (t, *J* = 7.0 Hz, 3 H); Anal. Calcd. For C<sub>19</sub>H<sub>18</sub>ClN<sub>5</sub>O<sub>2</sub>•0.1 H<sub>2</sub>O: C, 59.18; H, 4.76; N, 18.16. Found: C, 59.06; H, 4.49; N, 17.98.



10

## EXAMPLE 109

## COMPOUND 103



*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-

15

3-pyridinyl]-3-methoxy-propanamide (**Cmd 103**)

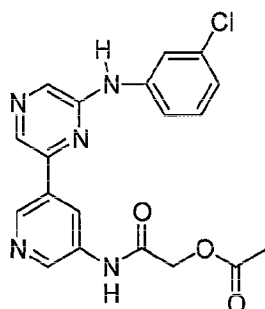
Following the procedure of Example 108, a mixture of **Cmd 67** (250 mg, 0.5 mmol) and 60% NaH (150 mg, 3.5 mmol), in THF (6 mL) was stirred under nitrogen at 20 °C for 0.5 h then 3-methoxypropanoyl chloride Compound **109a** (Compound **108a**; where R = (1-methoxy)methylene) (427 mg, 3.5 mmol) in THF (3 mL) was added. The reaction was then stirred at reflux for 18 h. Water was added then extracted with ethyl acetate. The ether layer was dried (Na<sub>2</sub>SO<sub>4</sub>) then concentrated under vacuum and purified by column chromatography

20

(EtOAc/acetone as solvent) to give 50 mg (26%) of **Cmd 103** (Compound **108b**; where R= (1-methoxy)methylene) as an off-white solid;  $^1\text{H}$  NMR (300 MHz,  $\text{D}^6\text{-DMSO}$ )  $\delta$  10.35 (s, 1 H), 9.89 (s, 1 H), 8.96 (s, 1 H), 8.81 (s, 1 H), 8.78 (s, 1 H), 8.60 (s, 1 H), 8.26 (s, 1 H), 7.88 (brs, 1 H), 7.84 (brs, 1 H), 7.40 (t,  $J$ = 8.1 Hz, 1 H), 7.04 (dd,  $J$ = 7.8, 1.1 Hz, 1 H), 3.66 (t,  $J$ = 6.1 Hz, 2 H), 3.26 (s, 3 H), 2.63 (t,  $J$ = 6.1 Hz, 2 H); Anal. Calcd. For  $\text{C}_{19}\text{H}_{18}\text{ClN}_5\text{O}_2 \cdot 0.2 \text{H}_2\text{O}$ : C, 58.90; H, 4.79; N, 18.08. Found: C, 59.07; H, 4.69; N, 17.93.

## EXAMPLE 110

## COMPOUND 104

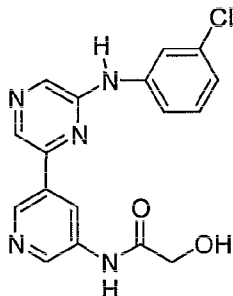


Following the procedure of Example 104, a mixture of **Cmd 67** (250 mg, 0.5 mmol) and 60% NaH (150 mg, 3.5 mmol), in THF (9 mL) was stirred under nitrogen at 20 °C for 0.5 h then acetoxyacetyl chloride Compound **110a** (Compound **104a**; where R= acetyloxyene) (478 mg, 3.5 mmol) was added. The reaction was then stirred at reflux for 18 h (conditions changed from Example 104). Water was added then extracted with ethyl acetate. The ether layer was dried ( $\text{Na}_2\text{SO}_4$ ) then concentrated under vacuum and purified by column chromatography (EtOAc/acetone as solvent) to give 70 mg of the Boc-protected amide Compound **110b** as an oil. The Boc-protected amide Compound **110b** was stirred in dichloromethane (1.3 mL) and TFA (0.42 mL) at 20 °C for 60 h before concentrated. Ammonium hydroxide solution was added to the residue until the pH was about 10-11 and was then extracted with ethyl acetate. The ethyl acetate layer was dried ( $\text{Na}_2\text{SO}_4$ ) then concentrated under vacuum and purified by column chromatography (EtOAc/acetone as solvent) to give 26 mg (13%) of **Cmd 104** (Compound **104c**; where R= acetyloxyene) AD-15 as an off-white solid;  $^1\text{H}$  NMR (300 MHz,  $\text{CD}_3\text{OD}$ )  $\delta$  8.91 (brs, 1 H), 8.75 (brs, 2 H), 8.42 (brs, 1 H), 8.10 (brs, 1 H), 7.83-7.56 (m, 2 H), 7.28 (m, 1 H), 6.96 (m, 1 H), 4.85

(s, 2 H), 2.21 (s, 3 H); MS (ES)  $m/z$ : 398 ( $M+1^+$ ).

## EXAMPLE 111

## COMPOUND 105



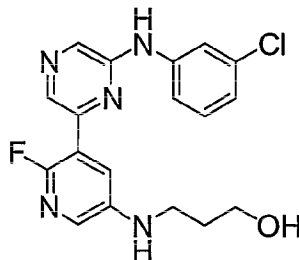
*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-

3-pyridinyl]-2-hydroxyacetamide (Cmd **105**)

A mixture of **Cmd 104** (prepared according to the procedure of Example 110)(26 mg, 0.065 mmol),  $K_2CO_3$  (5.4 mg, 0.04 mmol),  $H_2O$  (0.1 mL) and methanol (3.4 mL) was heated at reflux for 1 min. Crystals were recovered by filtration and purified by recrystallization from methanol to give 5 mg (22%) of **Cmd 105** as an off-white solid;  $^1H$  NMR (300 MHz,  $CD_3OD$ )  $\delta$  10.10 (s, 1 H), 9.89 (s, 1 H), 8.98-8.88 (m, 3 H), 8.60 (s, 1 H), 8.26 (s, 1 H), 7.89-7.86 (m, 2 H), 7.40 (t,  $J = 8.2$  Hz, 1 H), 7.04 (d,  $J = 7.2$  Hz, 1 H), 5.81 (m, 1 H), 4.08 (d,  $J = 5.5$  Hz, 2 H); FAB-HRMS ( $M+H^+$ ). Calcd. for  $C_{17}H_{14}ClN_5O_2$  356.0914, found 356.0927.

## EXAMPLE 112

## COMPOUND 106



Bromine (2.3 mL, 44.6 mmol) was added dropwise to a suspension of the 6-aminonicotinic acid Compound **112a** (5.08 g, 36.8 mmol) in water (20 mL) at 4 °C. After the completion of the addition, the cooling bath was removed and the reaction mixture was stirred at room temperature for 4.5 h. Saturated  $Na_2S_2O_5$

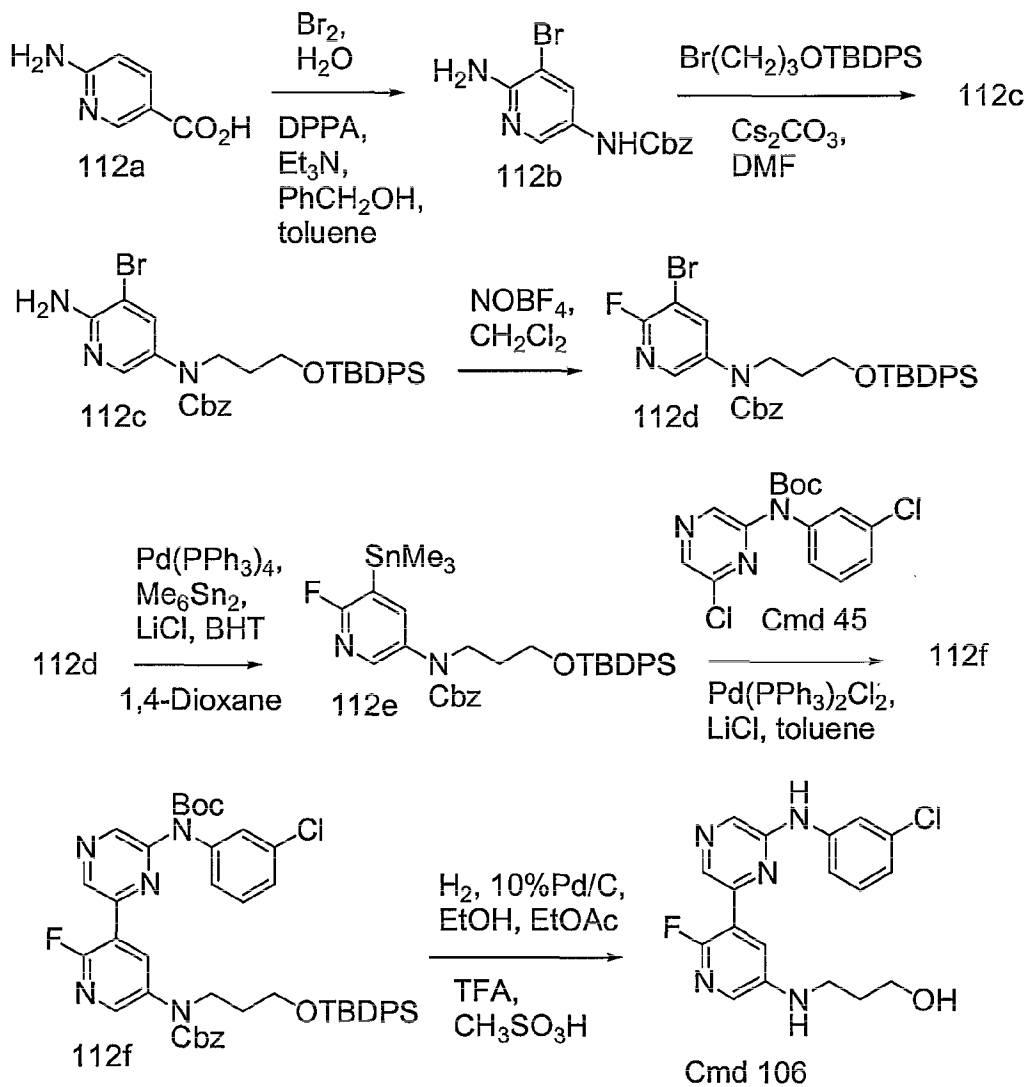
was added slowly to the stirred mixture. The solid was collected through filtration, washed with water, and dried under vacuum overnight to give 9.30 g of 6-amino-5-bromonicotinic acid along with 3,5-dibromo-2-aminopyridine in ~ 1:1 ratio as a greenish solid; MS (ES)  $m/z$ : 217 ( $M+H^+$ ). A mixture of the solid  
5 (4.00 g) containing 6-amino-5-bromonicotinic acid, DPPA (6.08 g, 22.1 mmol), triethylamine (2.80 g, 27.7 mmol), benzyl alcohol (3.8 mL, 36.8 mmol), and toluene (50 mL) was heated at 70 °C for 1 h, then 100 °C for 1 h. After concentration, the reaction mixture was purified by flash chromatography (EtOAc/hexane as solvent) to give 1.31 g (26% in 2 steps) of Compound **112b** as  
10 a yellow solid;  $^1H$  NMR (300 MHz,  $CDCl_3$ )  $\delta$  7.99 (brs, 1 H), 7.91(d,  $J$  = 2.3 Hz, 1 H), 7.39-7.34 (m, 5 H), 6.50 (brs, 1 H), 5.19 (s, 2 H), 4.79 (brs, 2 H); MS (ES)  $m/z$ : 324 ( $M+H^+$ ). Anal. Calcd. For  $C_{13}H_{12}BrN_3O_2 \cdot 0.1 H_2O$ : C, 48.20; H, 3.80; N, 12.97. Found: C, 48.40; H, 3.90; N, 12.64.

15 A mixture of Compound **112b** (685 mg, 2.13 mmol), (3-bromopropoxy)-*tert*-butyldiphenylsilane (965 mg, 2.56 mmol), and  $Cs_2CO_3$  (1.04 g, 3.19 mmol) in dry DMF (20 mL) was heated at 70 °C for 3 h. The reaction mixture was concentrated and purified by column chromatography (EtOAc/hexane as solvent) to give 1.06 g (81%) of Compound **112c** as a yellow oil;  $^1H$  NMR (300 MHz,  
20  $CDCl_3$ )  $\delta$  7.88 (brs, 1 H), 7.61-7.58 (m, 5 H), 7.51 (brs, 1 H), 7.41-7.30 (m, 10 H), 5.12 (s, 2 H), 4.93 (s, 2 H), 3.74 (t,  $J$  = 7.4 Hz, 2 H), 3.65 (t,  $J$  = 6.0 Hz, 2 H), 1.82-1.73 (m, 2 H), 1.00 (s, 9 H); MS (ES)  $m/z$ : 620 ( $M+H^+$ ). Nitrosonium tetrafluoroborate (170 mg, 1.45 mmol) was added to the solution of Compound **112c** (680 mg, 1.10 mmol) in  $CH_2Cl_2$  (20 mL) at 4 °C. After 1 h at 4 °C, more  
25  $NOBF_4$  (50 mg, 0.43 mmol) was added followed by the same amount of  $NOBF_4$  (50 mg, 0.43 mmol) after another 1 h. After stirring for total 3 h at 4 °C, water was added. The aqueous solution was extracted with  $CH_2Cl_2$ . The combined organic layers were dried, concentrated, and flash chromatographed (EtOAc/hexane) to give 425 mg (62%) of Compound **112d** as a yellow oil;  $^1H$   
30 NMR (300 MHz,  $CDCl_3$ )  $\delta$  8.24 (d,  $J$  = 2.3 Hz, 1 H), 7.84 (brs, 1 H), 7.59-7.56 (m, 5 H), 7.45-7.27 (m, 10 H), 5.15 (s, 2 H), 3.83 (m, 2 H), 3.65 (t,  $J$  = 5.9 Hz, 2 H), 1.79 (m, 2 H), 1.00 (s, 9 H); MS (ES)  $m/z$ : 645 ( $M+Na^+$ ). Anal. Calcd. For  $C_{32}H_{34}BrFN_2O_3Si \cdot 0.50 H_2O$ : C, 60.95; H, 5.59; N, 4.44. Found: C, 60.65; H, 5.24; N, 4.35.

A mixture of Compound **112d** (405 mg, 0.652 mmol), bis(trimethyltin) (427 mg, 1.30 mmol), tetrakis(triphenylphosphine) palladium (76 mg, 0.066 mmol), LiCl (110 mg, 2.59 mmol), and 2,6-di-*tert*-butyl-4-methylphenol (6 mg, 0.03 mmol) in anhydrous 1,4-dioxane (10 mL) was refluxed at 100 °C for 4.5 h under nitrogen. After removal of solvent under reduced pressure, the mixture was purified by flash chromatography (EtOAc/hexane as solvent) to give 375 mg (82%) of Compound **112e** as a clear oil; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 8.17 (s, 1 H), 7.59-7.57 (m, 5 H), 7.53 (s, 1 H), 7.44-7.27 (m, 10 H), 5.14 (s, 2 H), 3.84 (t, *J* = 7.5 Hz, 2 H), 3.66 (t, *J* = 5.8 Hz, 2 H), 1.82 (m, 2 H), 0.98 (s, 9 H), 0.38 (s, 9 H); MS (ES) *m/z*: 729 (M+Na<sup>+</sup>). A mixture of Compound **112e** (370 mg, 0.525 mmol), *N*-(*tert*-butoxycarbonyl)-*N*-(3-chlorophenyl)-2-amino-6-chloropyrazine **Cmd 45** (200 mg, 0.588 mmol), dichlorobis(triphenylphosphine)palladium (74 mg, 0.11 mmol), and LiCl (89 mg, 2.10 mmol) in anhydrous toluene (5 mL) was stirred at 100 °C for 19 h under nitrogen. After removal of solvent under reduced pressure, the residue was purified by flash chromatography (EtOAc/hexane as solvent) to give 140 mg (32%) of Compound **112f** as a yellow solid; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 9.15 (s, 1 H), 8.94 (d, *J* = 1.6 Hz, 1 H), 8.06 (s, 1 H), 7.89 (brs, 1 H), 7.59-7.52 (m, 5 H), 7.41-7.20 (m, 13 H), 7.06-7.04 (m, 1 H), 5.13 (s, 2 H), 3.78 (t, *J* = 7.3 Hz, 2 H), 3.62 (t, *J* = 5.9 Hz, 2 H), 1.76-1.70 (m, 2 H), 1.48 (s, 9 H), 0.95 (s, 9 H); MS (ES) *m/z*: 868 (M+Na<sup>+</sup>).

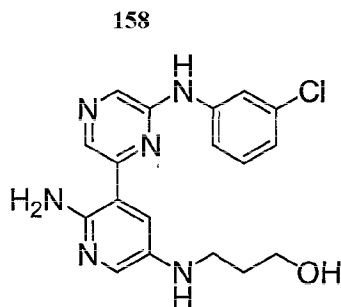
The mixture of Compound **112f** (100 mg, 0.118 mmol), 10% Pd/C (100 mg), EtOH (9 mL), and EtOAc (3 mL) was hydrogenated under 22 psi for 46 h at room temperature. After removal of solvents under reduced pressure, the residue was purified by flash chromatography (ethyl acetate/hexane as solvent) to give 55 mg (65%) of Compound **112f** as the des-Cbz yellow oil. Anal. Calcd. For C<sub>39</sub>H<sub>43</sub>ClFN<sub>5</sub>O<sub>3</sub>Si·0.30 H<sub>2</sub>O: C, 65.26; H, 6.12; N, 9.76. Found: C, 65.50; H, 6.30; N, 9.44. A solution of the yellow oil (68 mg, 0.096 mmol), TFA (1 mL), and CH<sub>3</sub>SO<sub>3</sub>H (3 drops) was stirred at room temperature for 5 h and then concentrated. A saturated NH<sub>4</sub>OH solution was added to the residue until the mixture was made basic followed by the addition of water. The precipitated solid was collected through filtration, washed with water, and dried under vacuum. The product was purified by flash chromatography on silica gel (using

EtOAc/MeOH as the solvent) to provide 30 mg (84%) of **Cmd 106** as a yellow solid;  $^1\text{H}$  NMR (300 MHz,  $\text{DMSO}-d_6$ )  $\delta$  9.90 (s, 1 H), 8.42 (s, 1 H), 8.25 (s, 1 H), 8.05 (s, 1 H), 7.64 (s, 1 H), 7.62 (s, 2 H), 7.36 (t,  $J = 8.1$  Hz, 1 H), 7.03 (d,  $J = 7.8$  Hz, 1 H), 6.02 (brs, 1 H), 4.52 (brs, 1 H), 3.54 (t,  $J = 5.9$  Hz, 2 H), 3.17 (m, 2 H), 1.76 (m, 2 H); MS (ES)  $m/z$ : 374 ( $\text{M}+\text{H}^+$ ).



## EXAMPLE 113

## COMPOUND 107

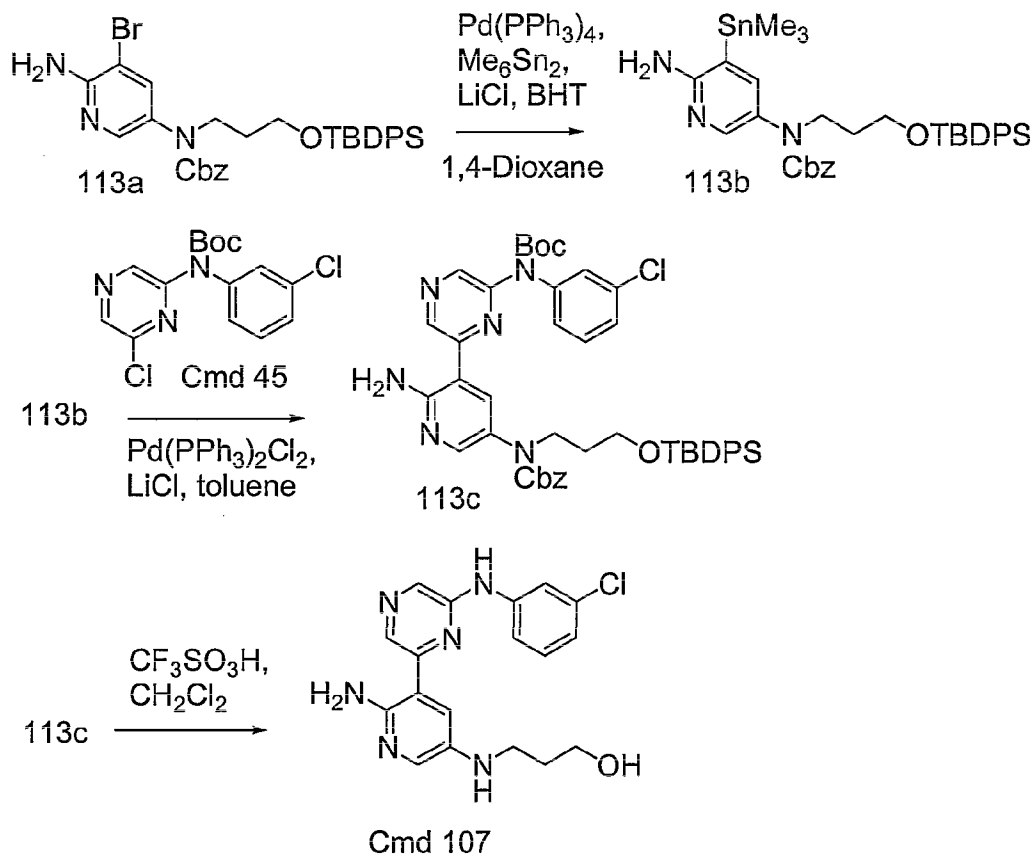


A mixture of Compound **113a** (1.25 g, 2.02 mmol), bis(trimethyltin) (1.00 g, 3.05 mmol), tetrakis(triphenylphosphine) palladium (240 mg, 0.208 mmol), LiCl (260 mg, 6.13 mmol), and 2,6-di-*tert*-butyl-4-methylphenol (20 mg, 0.091 mmol) in anhydrous 1,4-dioxane (25 mL) was refluxed at 100 °C for 3 h under nitrogen. After removal of solvent under reduced pressure, the residue was purified by flash chromatography (EtOAc/hexane as solvent) to give 1.05 g (74%) of Compound **113b** as a yellow oil; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 7.86 (brs, 1 H), 7.61-7.58 (m, 5 H), 7.43-7.28 (m, 11 H), 5.11 (brs, 2 H), 4.40 (s, 2 H), 3.75 (t, *J* = 7.6 Hz, 2 H), 3.66 (t, *J* = 6.0 Hz, 2 H), 1.85-1.76 (m, 2 H), 0.99 (s, 9 H), 0.34 (s, 9 H); MS (ES) *m/z*: 704 (M+H<sup>+</sup>). A mixture of Compound **113b** (1.05 g, 1.50 mmol), *N*-(*tert*-butoxycarbonyl)-*N*-(3-chlorophenyl)-2-amino-6-chloropyrazine **Cmd 45** (510 mg, 1.50 mmol), dichlorobis(triphenylphosphine)palladium (105 mg, 0.150 mmol), and LiCl (190 mg, 4.48 mmol) in anhydrous toluene (30 mL) was stirred at 100 °C for 2.5 h under nitrogen. After removal of solvent under reduced pressure, the residue was purified by flash chromatography (EtOAc/hexane as solvent) to give 830 mg (66%) of Compound **113c** as a yellow oil; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.00 (s, 1 H), 8.52 (brs, 1 H), 7.93 (s, 1 H), 7.66 (brs, 1 H), 7.59-7.55 (m, 5 H), 7.41-7.27 (m, 13 H), 7.14 (m, 1 H), 5.89 (s, 2 H), 5.11 (brs, 2 H), 3.77 (t, *J* = 7.4 Hz, 2 H), 3.65 (t, *J* = 5.9 Hz, 2 H), 1.84-1.75 (m, 2 H), 1.48 (s, 9 H), 0.97 (s, 9 H); MS (ES) *m/z*: 843 (M+H<sup>+</sup>). Anal. Calcd. For C<sub>47</sub>H<sub>51</sub>ClN<sub>6</sub>O<sub>5</sub>Si·1.70 H<sub>2</sub>O: C, 64.58; H, 6.27; N, 9.61. Found: C, 64.93; H, 6.18; N, 9.23. A solution of Compound **113c** (70 mg, 0.083 mmol), CF<sub>3</sub>SO<sub>3</sub>H (0.4 mL), and CH<sub>2</sub>Cl<sub>2</sub> (1 mL) was stirred at room temperature for 1.5 h and then concentrated. A saturated NH<sub>4</sub>OH solution was added to the residue at 4 °C until the mixture was made basic followed by the addition of water. The aqueous solution was discarded. The gummy material left in the reaction flask was washed with water, dried under vacuum, and purified by flash chromatography (CH<sub>2</sub>Cl<sub>2</sub>/MeOH as solvent) to provide 37



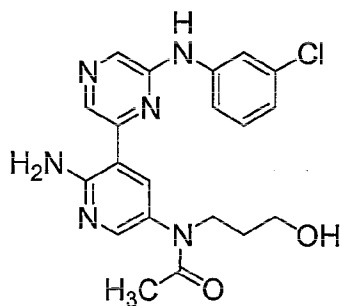
mg (76%) of **Cmd 107** as a dark yellow oil;  $^1\text{H}$  NMR (300 MHz,  $\text{MeOH-}d_4$ )  $\delta$  8.31 (s, 1 H), 8.07 (s, 1 H), 7.71 (s, 1 H), 7.61 (d,  $J = 2.5$  Hz, 1 H), 7.47 (m, 2 H), 7.29 (t,  $J = 8.0$  Hz, 1 H), 7.01 (d,  $J = 6.6$  Hz, 1 H), 3.71 (t,  $J = 6.2$  Hz, 2 H), 3.19 (t,  $J = 6.9$  Hz, 2 H), 1.85 (m, 2 H); MS (ES)  $m/z$ : 371 ( $\text{M} + \text{H}^+$ ).

5



### EXAMPLE 114

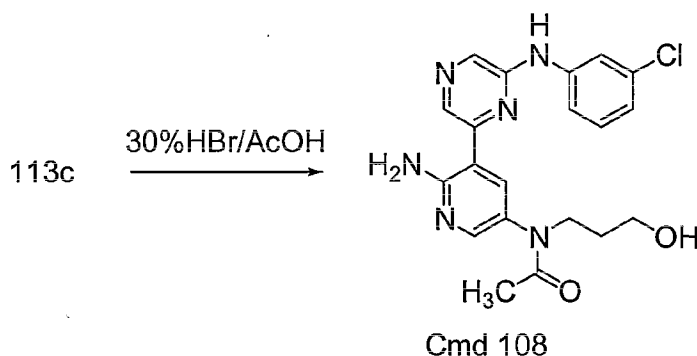
COMPOUND 108



A solution of Compound **113c** (128 mg, 0.152 mmol) and 30% HBr in AcOH (1.5 mL) was stirred at room temperature for 7 h and then concentrated.

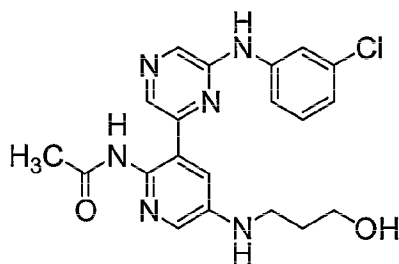
A saturated  $\text{NH}_4\text{OH}$  solution was added to the residue at 4 °C until the pH was ~11. The aqueous solution was discarded. The gummy material left in the reaction flask was washed with water, dried under vacuum, and purified by flash chromatography (EtOAc/MeOH as solvent) to provide 62 mg (60%) of **Cmd**

5 **108** as a yellow oil;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  8.37 (s, 1 H), 8.14 (s, 1 H), 7.71 (d,  $J = 2.6$  Hz, 1 H), 7.52 (s, 1 H), 7.33-7.25 (m, 4 H), 7.09-7.06 (m, 2 H), 5.77 (brs, 2 H), 4.22 (t,  $J = 6.2$  Hz, 2 H), 3.23 (t,  $J = 6.8$  Hz, 2 H), 2.08 (s, 3 H), 1.97 (m, 2 H); MS (ES)  $m/z$ : 413 ( $\text{M} + \text{H}^+$ ).



## EXAMPLE 115

## COMPOUND 109



15 A solution of Compound **113c** (58 mg, 0.069 mmol) in  $\text{CH}_3\text{CN}$  (2 mL) was added to a solution of *tert*-butyl nitrite (0.018 mL, 0.14 mmol),  $\text{CuBr}_2$  (23 mg, 0.10 mmol) and  $\text{CH}_3\text{CN}$  (0.5 mL) at room temperature. After stirring for 1.5 h, the solvent was evaporated and the residue was partitioned between  $\text{Et}_2\text{O}$  and diluted HCl aqueous solution. The organic layer was dried, concentrated, and

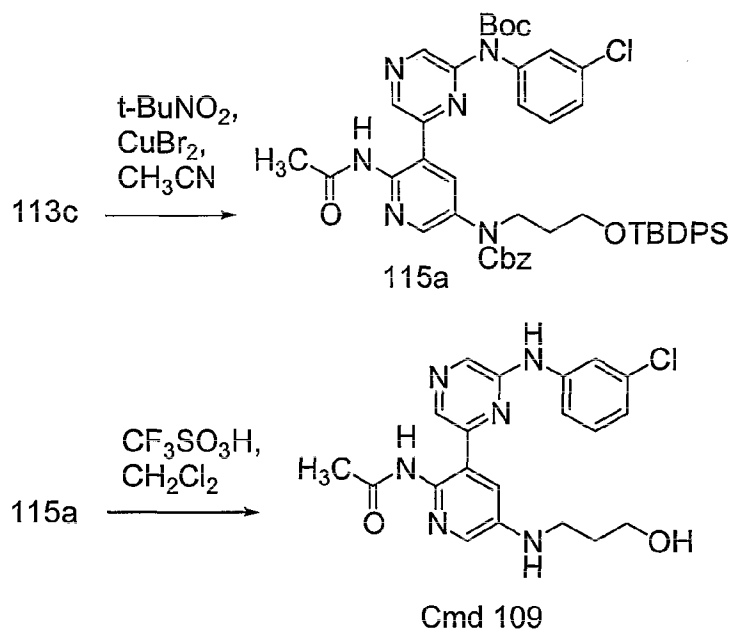
20 flash chromatographed (EtOAc/hexane) to provide 32 mg (53%) of Compound **115a** as a yellow oil;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.96 (s, 1 H), 8.81 (s, 1 H), 8.44 (brs, 1 H), 8.38 (d,  $J = 2.2$  Hz, 1 H), 7.74 (brs, 1 H), 7.60-7.57 (m, 5 H), 7.43-7.20 (m, 14 H), 5.17 (s, 2 H), 3.88 (t,  $J = 7.3$  Hz, 2 H), 3.67 (t,  $J = 6.0$  Hz, 2

H), 2.21 (s, 3 H), 1.84 (m, 2 H), 1.49 (s, 9 H), 0.98 (s, 9 H); MS (ES)  $m/z$ : 885 ( $M+H^+$ ). A solution of Compound 115a (83 mg, 0.094 mmol),  $CH_3SO_3H$  (0.5 mL), and  $CH_2Cl_2$  (1 mL) was stirred at room temperature for 6 h and then concentrated. A saturated  $NH_4OH$  solution was added to the residue at 4 °C until

5 the pH was ~10. The aqueous solution was discarded. The gummy material left in the reaction flask was washed with water, dried under vacuum, and purified by flash chromatography ( $CH_2Cl_2/MeOH$  as solvent) to provide 28 mg (72%) of

**Cmd 109** as a yellow solid;  $^1H$  NMR (300 MHz,  $MeOH-d_4$ )  $\delta$  8.18 (s, 1 H), 8.09 (s, 1 H), 7.87 (m, 2 H), 7.62 (d,  $J=7.3$  Hz, 1 H), 7.38 (d,  $J=2.4$  Hz, 1 H), 7.27

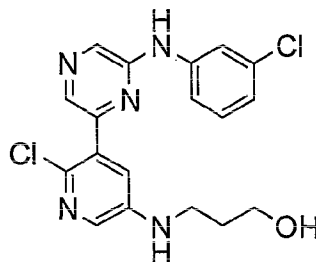
10 (t,  $J=8.1$  Hz, 1 H), 6.97 (dd,  $J=7.9, 1.1$  Hz, 1 H), 3.70 (t,  $J=6.1$  Hz, 2 H), 3.29 (m, 2 H), 1.90 (s, 3 H), 1.88 (m, 2 H); MS (ES)  $m/z$ : 413 ( $M+H^+$ ).



15

## EXAMPLE 116

## COMPOUND 110



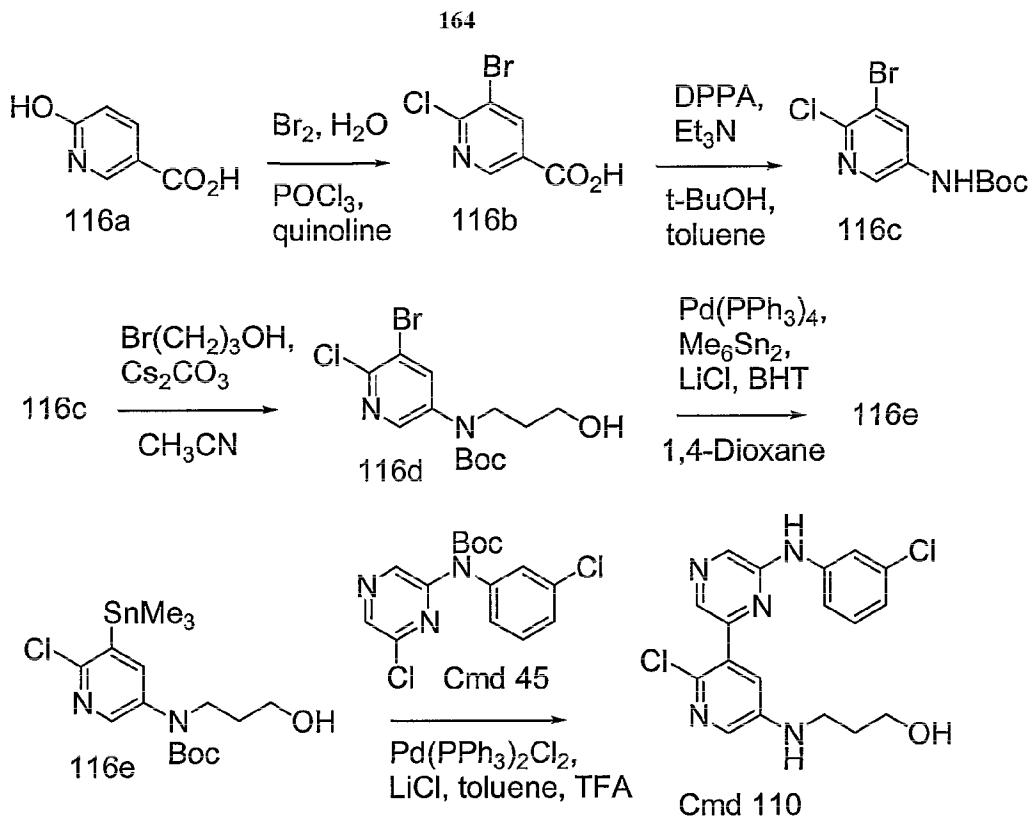
Bromine (4.2 mL, 81.4 mmol) was added dropwise to the suspension of 6-

hydroxynicotinic acid Compound **116a** (8.00 g, 57.6 mmol) in water (30 mL) at 4 °C. After the completion of the addition, the cooling bath was removed and the reaction mixture was stirred at room temperature for 4 h. Saturated Na<sub>2</sub>S<sub>2</sub>O<sub>5</sub> was added slowly to the stirred mixture until the brown mixture became white. The solid was collected through filtration, washed with water, and dried under vacuum overnight to give 12.17 g (97%) of 6-hydroxy-5-bromonicotinic acid as an off-white solid; <sup>1</sup>H NMR (300 MHz, DMSO-*d*<sub>6</sub>) δ 12.95 (brs, 1 H), 12.55 (brs, 1 H), 8.16 (s, 1 H), 8.04 (s, 1 H). Quinoline (1.0 mL, 8.47 mmol) was slowly added to the solution of POCl<sub>3</sub> (2.0 mL, 21.5 mmol), followed by 6-hydroxy-5-bromonicotinic acid (3.92 g, 18.0 mmol) at room temperature. After heating at 120 °C for 2 h, the reaction was quenched by addition of water dropwise at ~100 °C. After the mixture was cooled at 4 °C for a few hours, the solid was collected through filtration, washed with water, and dried under vacuum overnight to give 3.68 g (87%) of Compound **116b** as an off-white solid; <sup>1</sup>H NMR (300 MHz, DMSO-*d*<sub>6</sub>) δ 8.86 (s, 1 H), 8.55 (s, 1 H); MS (ES) m/z: 236 (M-H<sup>+</sup>).

A mixture of Compound **116b** (2.00 g, 8.46 mmol), DPPA (3.49 g, 12.7 mmol), triethylamine (2.56 g, 25.3 mmol), *t*-BuOH (18 mL), and toluene (20 mL) was heated at 65 °C for 3 h, then 100 °C for 1.5 h. After removal of solvent under reduced pressure, the reaction mixture was purified by flash chromatography (EtOAc/hexane as solvent) to give 3.04 g of Compound **116c** (containing impurities) as an off-white solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.36 (s, 1 H), 8.19 (d, *J* = 2.3 Hz, 1 H), 7.01 (brs, 1 H), 1.52 (s, 9 H); MS (ES) m/z: 309 (M+H<sup>+</sup>). Anal. Calcd. For C<sub>10</sub>H<sub>12</sub>BrClN<sub>2</sub>O<sub>2</sub>: C, 39.05; H, 3.93; N, 9.11. Found: C, 38.94; H, 4.01; N, 9.06. A mixture of Compound **116c** (710 mg, 2.31 mmol), 3-bromo-1-propanol (400 mg, 2.88 mmol), and Cs<sub>2</sub>CO<sub>3</sub> (1.13 g, 3.47 mmol) in dry CH<sub>3</sub>CN (10 mL) was heated at 65 °C for 17 h. The reaction mixture was concentrated and purified by column chromatography (EtOAc/hexane as solvent) to give 255 mg (30%) of Compound **116d** as a clear oil; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.22 (d, *J* = 2.4 Hz, 1 H), 7.84 (d, *J* = 2.3 Hz, 1 H), 3.80 (t, *J* = 6.5 Hz, 2 H), 3.67 (m, 2 H), 1.74 (m, 2 H), 1.44 (s, 9 H); MS (ES) m/z: 389 (M+Na<sup>+</sup>). A mixture of Compound **116d** (145 mg, 0.396 mmol), bis(trimethyltin) (260 mg, 0.794 mmol), tetrakis(triphenylphosphine) palladium

(46 mg, 0.040 mmol), LiCl (68 mg, 1.6 mmol), and 2,6-di-*tert*-butyl-4-methylphenol (4 mg, 0.02 mmol) in anhydrous 1,4-dioxane (5 mL) was refluxed at 100 °C for 3 h under nitrogen. After removal of solvent under reduced pressure, the residue was purified by flash chromatography (CH<sub>2</sub>Cl<sub>2</sub>/EtOAc as solvent) to give 149 mg (84%) of Compound **116e** as a clear oil; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.13 (d, *J* = 2.9 Hz, 1 H), 7.50 (d, *J* = 2.9 Hz, 1 H), 3.79 (t, *J* = 6.3 Hz, 2 H), 3.67 (m, 2 H), 1.71 (m, 2 H), 1.42 (s, 9 H), 0.42 (s, 9 H); MS (ES) *m/z*: 451 (M+H<sup>+</sup>).

10           A mixture of Compound **116e** (145 mg, 0.323 mmol), *N*-(*tert*-butoxycarbonyl)-*N*-(3-chlorophenyl)-2-amino-6-chloropyrazine **Cmd 45** (120 mg, 0.353 mmol), dichlorobis(triphenylphosphine)palladium (23 mg, 0.033 mmol), and LiCl (55 mg, 1.3 mmol) in anhydrous toluene (4 mL) was stirred at 110 °C for 32 h under nitrogen. After removal of solvent under reduced pressure, 15 the residue was purified by flash chromatography (EtOAc/hexane as solvent) to give 28 mg (15%) of the coupling compound as a yellow solid. A solution of the yellow solid (28 mg, 0.047 mmol), TFA (1 mL), and CH<sub>2</sub>Cl<sub>2</sub> (1 mL) was stirred at room temperature for 1.5 h and then concentrated. A saturated NH<sub>4</sub>OH solution was added to the residue until the mixture was made basic, followed by 20 the addition of water. The precipitated solid was collected through filtration, washed with water, and dried under vacuum. The product was purified by flash chromatography on silica gel (EtOAc/CH<sub>2</sub>Cl<sub>2</sub> as solvent) to provide 13 mg (70%) of **Cmd 110** as a yellow solid; <sup>1</sup>H NMR (300 MHz, DMSO-*d*<sub>6</sub>) δ 9.89 (s, 1 H), 8.26 (s, 2 H), 8.07 (s, 1 H), 7.86 (d, *J* = 2.9 Hz, 1 H), 7.57 (d, *J* = 8.3 Hz, 1 H), 7.32 (t, *J* = 8.1 Hz, 1 H), 7.20 (d, *J* = 2.9 Hz, 1 H), 6.99 (d, *J* = 6.0 Hz, 1 H), 25 6.26 (t, *J* = 5.2 Hz, 1 H), 4.50 (brs, 1 H), 3.50 (m, 2 H), 3.15 (m, 2 H), 1.72 (m, 2 H); MS (ES) *m/z*: 390 (M+H<sup>+</sup>).



## EXAMPLE 117

## COMPOUND 111

5

2.0 M TMSCHN<sub>2</sub> in hexane (6.4 mL, 12.8 mmol) was slowly added to a suspension of Compound 116b (2.00 g, 8.46 mmol) in C<sub>6</sub>H<sub>6</sub> (10 mL) and MeOH (10 mL) at 4 °C. After 15 min, the cooling bath was removed. The solution was stirred at room temperature for 1 h, concentrated under reduced pressure, and flash chromatographed to give 2.03 g (96%) of methyl 5-bromo-6-chloronicotinic acid as a white solid. The mixture of methyl 5-bromo-6-chloronicotinic acid (4.00 g, 16.0 mmol), KF (2.78 g, 47.9 mmol), tetraphenylphosphonium bromide (3.35 g, 8.0 mmol) and CH<sub>3</sub>CN (100 mL) was heated at 80 °C for 4.5 days and filtered. The filtrate was concentrated and flash chromatographed (EtOAc/hexane as solvent) to provide 2.40 g (64%) of Compound 117a as white crystals; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.78 (m, 1 H), 8.58 (dd, *J* = 8.2, 2.1 Hz, 1 H), 3.97 (s, 3 H); MS (ES) *m/z*: 235 (M+H<sup>+</sup>). Anal. Calcd. For C<sub>7</sub>H<sub>5</sub>BrFNO<sub>2</sub>: C, 35.93; H, 2.15; N, 5.99. Found: C, 36.10; H, 2.43; N, 5.90. A mixture of Compound 117a (2.02 g, 8.63 mmol), bis(trimethyltin)

10

15

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(3.40 g, 10.4 mmol), tetrakis(triphenylphosphine) palladium (0.500 g, 0.433 mmol), LiCl (1.10 g, 25.9 mmol), and 2,6-di-*tert*-butyl-4-methylphenol (76 mg, 0.34 mmol) in anhydrous 1,4-dioxane (40 mL) was refluxed at 100 °C for 2 h under nitrogen. After removal of solvent under reduced pressure, the mixture  
5 was purified by flash chromatography (EtOAc/hexane as solvent) to give 2.72 g (99%) of Compound **117b** as white crystals; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 8.81 (d, *J* = 2.4 Hz, 1 H), 8.42 (dd, *J* = 6.4, 2.5 Hz, 1 H), 3.94 (s, 3 H), 0.42 (s, 9 H); MS (ES) *m/z*: 320 (M+H<sup>+</sup>).

10 A mixture of Compound **117b** (285 mg, 0.896 mmol), *N*-(*tert*-butoxycarbonyl)-*N*-(3-chlorophenyl)-2-amino-6-chloropyrazine **Cmd 45** (335 mg, 0.985 mmol), dichlorobis(triphenylphosphine)palladium (63 mg, 0.090 mmol), and LiCl (152 mg, 3.58 mmol) in anhydrous toluene (5 mL) was stirred at 100 °C for 32 h under nitrogen. After removal of solvent under reduced  
15 pressure, the residue was purified by flash chromatography (EtOAc/hexane as solvent) to give 234 mg (57%) of Compound **117c** as a white solid; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.13 (s, 1 H), 8.95 (d, *J* = 2.3 Hz, 1 H), 8.86 (m, 1 H), 8.67 (dd, *J* = 9.1, 2.4 Hz, 1 H), 7.42-7.37 (m, 2 H), 7.31 (m, 1 H), 7.16 (m, 1 H), 3.96 (s, 3 H), 1.50 (s, 9 H); MS (ES) *m/z*: 481 (M+Na<sup>+</sup>). Anal. Calcd. For  
20 C<sub>22</sub>H<sub>20</sub>ClFN<sub>4</sub>O<sub>4</sub>: C, 57.58; H, 4.39; N, 12.21. Found: C, 57.67; H, 4.44; N, 12.03. The mixture of NaCN (60 mg, 1.22 mmol) and DMF (2 mL) was stirred at 100 °C for 1.5 h. After cooling to 4 °C, the solution of Compound **117c** (187 mg, 0.407 mmol) in DMF (3 mL) was added. After stirring at room temperature for 1 h, water was added. The aqueous solution was extracted with Et<sub>2</sub>O (x 3),  
25 and the combined organic layers were washed with water, dried, concentrated, and flash chromatographed (EtOAc/hexane as solvent) to give 135 mg (71%) of Compound **117d** as a yellow oil; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.29 (s, 1 H), 9.26 (d, *J* = 1.9 Hz, 1 H), 8.87 (s, 1 H), 8.52 (d, *J* = 1.9 Hz, 1 H), 7.39-7.28 (m, 3 H), 7.21-7.18 (m, 1 H), 4.01 (s, 3 H), 1.49 (s, 9 H); MS (ES) *m/z*: 488 (M+Na<sup>+</sup>).

30

The solution of Compound **117d** (165 mg, 0.354 mmol), 1.0 M LiOH (0.5 mL, 0.5 mmol), THF (4 mL), and water (0.5 mL) was stirred at room temperature for 1.5 h. More LiOH (12 mg, 0.5 mmol) was added, and the solution was stirred for another 1 h then concentrated. AcOH was added to the

residue until the pH was ~ 5-6. The precipitated solid was collected through filtration, rinsed with water, and dried overnight to give 155 mg (97%) of acid. A mixture of the acid (155 mg, 0.343 mmol), DPPA (123 mg, 0.447 mmol), triethylamine (70 mg, 0.69 mmol), *t*-BuOH (2 mL), and toluene (4 mL) was

5 heated at 70 °C for 1 h, then 100 °C for 2.5 h. After removal of the solvents under reduced pressure, the reaction mixture was purified by flash chromatography (EtOAc/hexane as solvent) to give 124 mg (69%) of Compound **117e** as a clear oil; <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) δ 9.17 (s, 1 H), 8.82 (s, 1 H), 8.48 (d, *J* = 2.5 Hz, 1 H), 8.33 (d, *J* = 2.4 Hz, 1 H), 7.37-7.27 (m, 3 H), 7.22-7.18

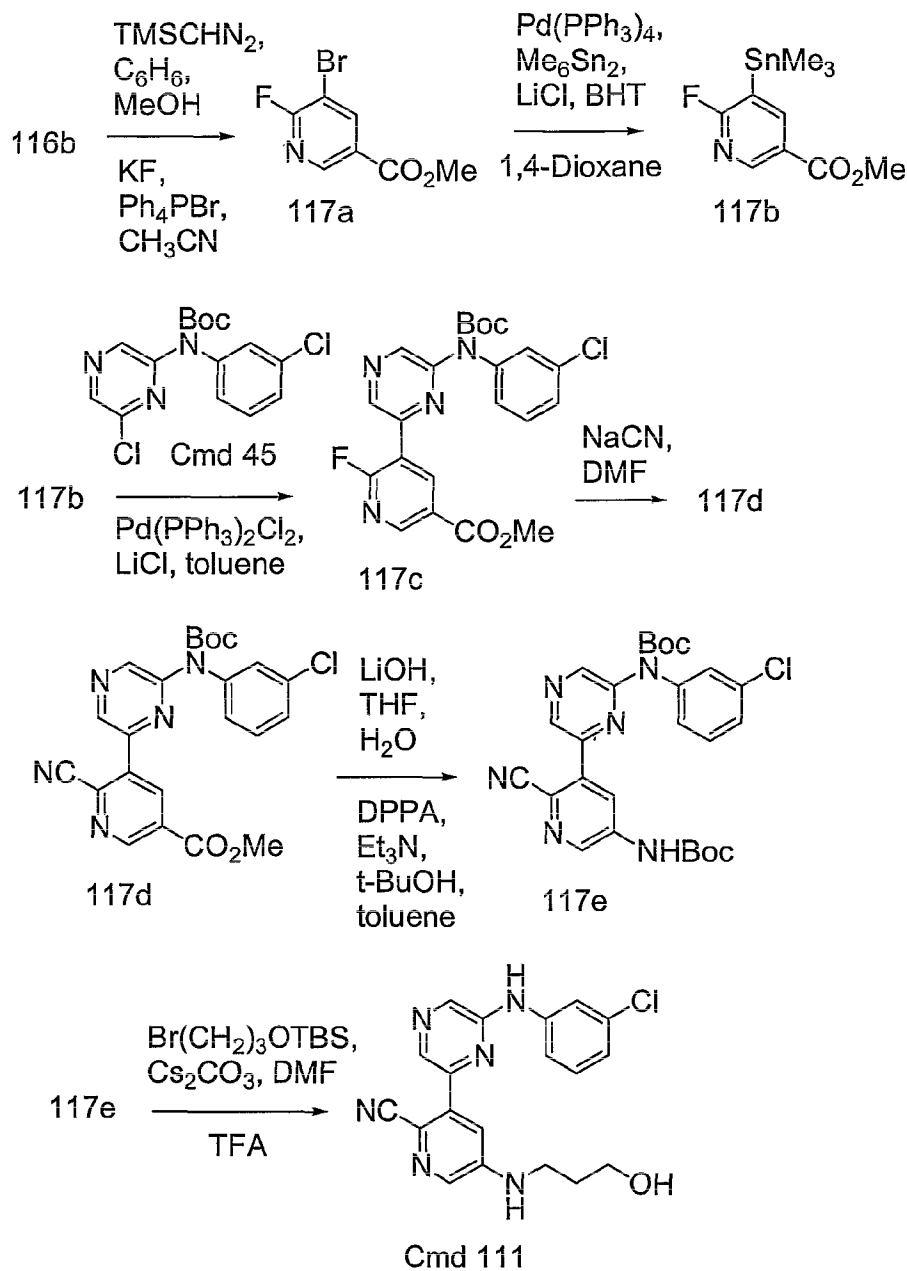
10 (m, 1 H), 6.82 (brs, 1 H), 1.53 (s, 9 H), 1.49 (s, 9 H); MS (ES) *m/z*: 545 (M+Na<sup>+</sup>). A mixture of Compound **117e** (114 mg, 0.218 mmol), (3-bromopropoxy)-*tert*-butyldimethylsilane (110 mg, 0.435 mmol), and Cs<sub>2</sub>CO<sub>3</sub> (170 mg, 0.521 mmol) in dry DMF (5 mL) was heated at 70 °C for 1 h. The reaction mixture was concentrated and purified by column chromatography

15 (EtOAc/hexane as solvent) to give 144 mg (95%) of the *N*-alkylated compound as a clear oil. A solution of the oil (144 mg, 0.207 mmol) and TFA (2 mL) was stirred at room temperature for 2 h and then concentrated. A saturated NH<sub>4</sub>OH solution was added to the residue until the mixture was made basic followed by the addition of water. The precipitated solid was collected through filtration,

20 washed with water, and dried under vacuum. The product was purified by flash chromatography on silica gel (EtOAc/MeOH as solvent) to provide 8 mg (10%) of **Cmd 111** as a yellow solid; <sup>1</sup>H NMR (300 MHz, DMSO-*d*<sub>6</sub>) δ 9.96 (s, 1 H), 8.38 (s, 1 H), 8.34 (s, 1 H), 8.15 (d, *J* = 1.7 Hz, 1 H), 8.12 (s, 1 H), 7.63 (d, *J* = 8.1 Hz, 1 H), 7.33 (t, *J* = 8.1 Hz, 1 H), 7.19 (m, 2 H), 7.01 (d, *J* = 7.8 Hz, 1 H),

25 4.55 (t, *J* = 5.0 Hz, 1 H), 3.51 (m, 2 H), 3.26 (m, 2 H), 1.74 (m, 2 H); MS (ES) *m/z*: 381 (M+H<sup>+</sup>).





### EXAMPLE 118

### VEGF-R Screening Assay

5 A kinase reaction mixture was prepared containing 50 mM Tris-HCl  
pH=8, 10 mM MgCl<sub>2</sub>, 0.1 mM Na<sub>3</sub>PO<sub>4</sub>, 1 mM DTT, 10 μM ATP, 0.025 μM  
biotinylated peptide substrate and 0.8 μCi per well <sup>33</sup>P-γ-ATP [2000-3000  
Ci/mmol]. 70 μl of the kinase reaction mixture was dispensed into the well of a  
streptavidin coated FlashPlate™ (Cat. # SMP103, NEN, Boston, MA). Then 1 μl  
10 of test compound stock in 100% DMSO was added to the wells resulting in a

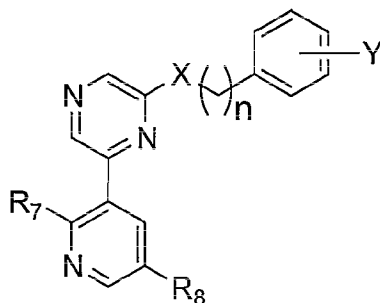
final concentration of 1% DMSO in the reaction with a 100  $\mu$ l final reaction volume. Next, soluble rat tyrosine kinase containing an N-terminal 6XHIS tag was diluted in 50 mM Tris-HCl pH=8.0, 0.1% BSA at a concentration of 5 ng per microliter and 30  $\mu$ l (150ng enzyme per test well) was added to each well to  
 5 initiate the reaction. The reaction was incubated for one hour at 30°C. At the end of the 1-hour incubation, the reaction was terminated by aspirating the reaction mixture from the plate and washing the wells twice with PBS containing 100 mM EDTA. The PLC1 biotinylated peptide substrate becomes immobilized on the Flashplate™ and the incorporation of  $^{33}\text{P}$ - $\gamma$ -ATP was measured by reading  
 10 the plate on a scintillation counter. Inhibition of the enzymatic activity of the VEGF-R was measured by observing a reduced amount of  $^{33}\text{P}$ - $\gamma$ -ATP incorporated into the immobilized peptide.


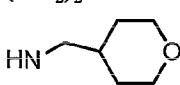
IC<sub>50</sub> data for VEGF-R and CDK are shown in Tables 1 to 3. IC<sub>50</sub> values  
 15 listed as >10 or >100 indicate no observed 50% inhibition at the highest dose tested, nor was an inhibition maxima observed. The term n.d. means not tested.

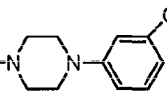
Compared to VEGF-R kinase inhibitory pyrazine derivative 3-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-propanol (Cmd 4),  
 20 compounds 52, 57, 62, 87, 88 and 89 were prepared with variations on the Y position.

Table 1

**X-[Y-phenyl-(CH<sub>2</sub>)<sub>n</sub>]-6-(5-R<sub>8</sub>-3-pyridinyl)-2-pyrazinamine  
 derivatives**

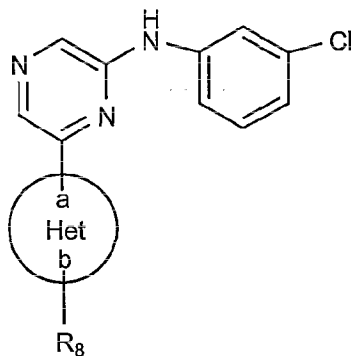


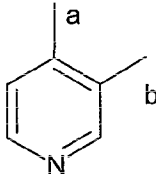
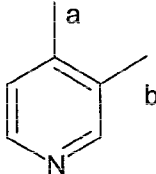
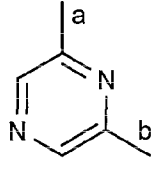
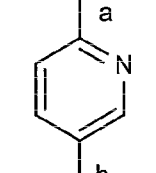
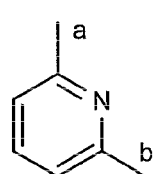
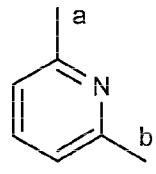
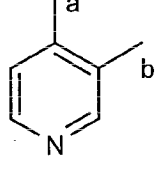
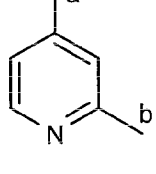
Cmd	X	n	R <sub>7</sub>	R <sub>8</sub>	Y	CDK IC <sub>50</sub> (uM)	VEGF-R IC <sub>50</sub> (uM)
1	NH	0	H	CO <sub>2</sub> C <sub>2</sub> H <sub>5</sub>	3-Cl	>10	nd
4	NH	0	H	NH(CH <sub>2</sub> ) <sub>3</sub> OH	3-Cl	5.96	0.08
5	NH	0	H	NH <sub>2</sub>	3-Cl	11.69	1.16
31	NH	0	H	NH(CH <sub>2</sub> ) <sub>2</sub> OH	3-Cl	~ 10	0.15
32	NH	0	H	NH(CH <sub>2</sub> ) <sub>4</sub> OH	3-Cl	>100	0.06
33	NH	0	H	NH(CH <sub>2</sub> ) <sub>2</sub> N(CH <sub>3</sub> ) <sub>2</sub>	3-Cl	~ 10	0.07
34	NH	0	H	NH(CH <sub>2</sub> ) <sub>3</sub> - (morpholine)	3-Cl	>100	0.18
35	NH	0	H	NH(CH <sub>2</sub> ) <sub>3</sub> N(CH <sub>3</sub> ) <sub>2</sub>	3-Cl	~ 10	0.09
36	NH	0	H	CONH(CH <sub>2</sub> ) <sub>2</sub> OCH <sub>3</sub>	3-Cl	>100	~10
37	NH	0	H	CONH(CH <sub>2</sub> ) <sub>3</sub> N(CH <sub>3</sub> ) <sub>2</sub>	3-Cl	>100	5.5
38	NH	0	H	CONH(CH <sub>2</sub> ) <sub>2</sub> N(CH <sub>3</sub> ) <sub>2</sub>	3-Cl	3.69	4.3
39	NH	0	H	CONH(CH <sub>2</sub> ) <sub>3</sub> OH	3-Cl	34.8	2.5
40	NH	0	H	CONH(CH <sub>2</sub> ) <sub>3</sub> OC <sub>2</sub> H <sub>5</sub>	3-Cl	>100	>100
41	NH	0	H	NHCOCH <sub>2</sub> OCH <sub>3</sub>	3-Cl	>100	0.36
42	NH	0	H	NHCO-(4-N(CH <sub>3</sub> ) <sub>2</sub> - phenyl)	3-Cl	>100	>100
43	NH	0	H	NHCO-3-pyridine	3-Cl	>100	1.12
52	NH	0	H	NH(CH <sub>2</sub> ) <sub>3</sub> OH	3-F	~100	0.17
57	NH	0	H	NH(CH <sub>2</sub> ) <sub>3</sub> OH	3-OCH <sub>3</sub>	81.38	0.81
62	NH	1	H	NH(CH <sub>2</sub> ) <sub>3</sub> OH	H	34.38	1.05
69	NH	0	H	NH(CH <sub>2</sub> ) <sub>3</sub> -piperazine	3-Cl	>10	0.364
70	NH	0	H	NH(CH <sub>2</sub> ) <sub>4</sub> -(4-pyridine)	3-Cl	10	0.295
71	NH	0	H	NH(CH <sub>2</sub> ) <sub>3</sub> -(4-pyridine)	3-Cl	>10	0.052
72	NH	0	H	NH(CH <sub>2</sub> ) <sub>3</sub> -(3-pyridine)	3-Cl	>10	0.089
73	NH	0	H	NH(CH <sub>2</sub> ) <sub>3</sub> -(1- piperidine)	3-Cl	3.24	0.105
74	NH	0	H	NHCO-N 	3-Cl	>10	0.578
75	NH	0	H	NH(CH <sub>2</sub> ) <sub>3</sub> -(1- pyrazole)	3-Cl	>10	0.079
76	NH	0	H	NH(CH <sub>2</sub> ) <sub>3</sub> -(1,2,4- triazole)	3-Cl	>10	0.052
77	NH	0	H	NH(CH <sub>2</sub> ) <sub>3</sub> -(1- imidazole)	3-Cl	>10	0.030
78	NH	0	H	NH(CH <sub>2</sub> ) <sub>2</sub> O(CH <sub>2</sub> ) <sub>2</sub> O (CH <sub>2</sub> ) <sub>2</sub> OH	3-Cl	>10	0.282
79	NH	0	H	HN 	3-Cl	>10	0.475
80	NH	0	H	NH(CH <sub>2</sub> ) <sub>3</sub> -C <sub>6</sub> H <sub>5</sub>	3-Cl	>10	2.277

<b>81</b>	NH	0	H	NHCH <sub>2</sub> CON(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub>	3-Cl	>10	1.102
<b>82</b>	NH	0	H	NHCH <sub>2</sub> C <sub>6</sub> H <sub>5</sub>	3-Cl	>10	4.3
<b>83</b>	NH	0	H	NH(CH <sub>2</sub> ) <sub>2</sub> OC <sub>6</sub> H <sub>5</sub>	3-Cl	>10	>10
<b>84</b>	NH	0	H	NH(CH <sub>2</sub> ) <sub>3</sub> CO <sub>2</sub> C <sub>2</sub> H <sub>5</sub>	3-Cl	2.03	0.125
<b>85</b>	NH	0	H	NH(CH <sub>2</sub> ) <sub>2</sub> O(CH <sub>2</sub> ) <sub>2</sub> OC H <sub>3</sub>	3-Cl	>10	0.085
<b>86</b>	NH	0	H	NH(CH <sub>2</sub> ) <sub>3</sub> -N 	3-Cl	>10	>10
<b>87</b>	NH	0	H	NH(CH <sub>2</sub> ) <sub>3</sub> -(4-pyridine)	4-Cl	>10	1.0
<b>88</b>	NH	0	H	NH(CH <sub>2</sub> ) <sub>3</sub> -(4-pyridine)	4-OCH <sub>3</sub>	>10	0.154
<b>89</b>	NH	0	H	NH(CH <sub>2</sub> ) <sub>3</sub> -(4-pyridine)	3,4-Cl <sub>2</sub>	>10	0.268
<b>96</b>	O	0	H	NH(CH <sub>2</sub> ) <sub>3</sub> OH	3-Cl	>10	>10
<b>98</b>	NH	0	H	NHCOCH <sub>2</sub> O(CH <sub>2</sub> ) <sub>2</sub> O CH <sub>3</sub>	3-Cl	>10	0.99
<b>99</b>	NH	0	H	NHCOCH <sub>2</sub> OPh	3-Cl	>10	>10
<b>100</b>	NH	0	H	NHCO(CH <sub>2</sub> ) <sub>3</sub> OPh	3-Cl	>10	>10
<b>101</b>	NH	0	H	NHCOCH <sub>2</sub> OCH <sub>2</sub> Ph	3-Cl	>10	>10
<b>102</b>	NH	0	H	NHCOCH <sub>2</sub> OCH <sub>2</sub> CH <sub>3</sub>	3-Cl	>10	0.93
<b>103</b>	NH	0	H	NHCO(CH <sub>2</sub> ) <sub>2</sub> OCH <sub>3</sub>	3-Cl	>10	0.59
<b>105</b>	NH	0	H	NHCOCH <sub>2</sub> OH	3-Cl	>10	0.41
<b>106</b>	NH	0	F	NH(CH <sub>2</sub> ) <sub>3</sub> OH	3-Cl	>10	0.138- 0.365
<b>107</b>	NH	0	NH <sub>2</sub>	NH(CH <sub>2</sub> ) <sub>3</sub> OH	3-Cl	>10	1.36
<b>109</b>	NH	0	NHCO CH <sub>3</sub>	NH(CH <sub>2</sub> ) <sub>3</sub> OH	3-Cl	>10	>10
<b>110</b>	NH	0	Cl	NH(CH <sub>2</sub> ) <sub>3</sub> OH	3-Cl	>10	>10
<b>111</b>	NH	0	CN	NH(CH <sub>2</sub> ) <sub>3</sub> OH	3-Cl	>10	>10

### Table 2

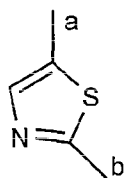
***N*-(3-chlorophenyl)-6-(R<sub>8</sub>-Het)-2-pyrazinamine derivatives**



Cmd	Het	R <sub>8</sub>	CDK IC <sub>50</sub> (uM)	VEGF-R IC <sub>50</sub> (uM)
27		OCON(Et) <sub>2</sub>	>10	n.d.
28		OH	>10	>10
90		NH(CH <sub>2</sub> ) <sub>3</sub> OH	>10	0,372
91		NH(CH <sub>2</sub> ) <sub>3</sub> OH	>10	>10
47		OH	5.76	~100
92		NH(CH <sub>2</sub> ) <sub>3</sub> OH	>10	>10
93		NH(CH <sub>2</sub> ) <sub>3</sub> OH	2.218	0.761
94		NH(CH <sub>2</sub> ) <sub>3</sub> OH	~0.5	~0.5

172

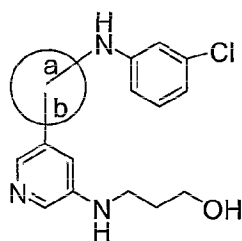
97

 $\text{NH}(\text{CH}_2)_3\text{OH}$ 

6.15

0.416

Table 3



Cmd	Het	CDK IC <sub>50</sub> (uM)	VEGF- RIC <sub>50</sub> (uM)
10	<p>A pyrimidine ring with nitrogen atoms at the top-left and bottom-right. A methyl group is attached at the top position (C5). A substituent 'a' is attached at the top-right position (C2), and a substituent 'b' is attached at the bottom position (C4).</p>	>10	0.84
15	<p>A pyrimidine ring with nitrogen atoms at the top-left and bottom-right. A substituent 'a' is attached at the top position (C2), and a substituent 'b' is attached at the bottom position (C4).</p>	>10	>10
20	<p>A pyrimidine ring with nitrogen atoms at the top-left and bottom-right. A substituent 'a' is attached at the top position (C2), and a substituent 'b' is attached at the bottom position (C4).</p>	>10	>10
25	<p>A pyrimidine ring with nitrogen atoms at the top-left and bottom-right. A substituent 'a' is attached at the top position (C2), and a substituent 'b' is attached at the bottom position (C4).</p>	>10	>10
68	<p>A pyrimidine ring with nitrogen atoms at the top-left and bottom-right. A substituent 'a' is attached at the top position (C2), and a substituent 'b' is attached at the bottom position (C4).</p>	2.40	>10

## EXAMPLE 119

*Kinase Selectivity Assays*

Assays to test compound inhibition of other kinases were preformed using methods that measure the amount of phosphorylation of a biotinylated peptide substrate. Biotinylated peptide substrates were selected from the literature as appropriate for the enzyme being evaluated. The general procedure used to assay for kinase activity is as follows: A kinase reaction mix was prepared in 50 mM Tris-HCl pH=8, 10 mM MgCl<sub>2</sub>, 0.1 mM Na<sub>3</sub>VO<sub>4</sub>, 1 mM DTT, 5-10 μM ATP, 0.25-1 μM biotinylated peptide substrate, 0.2-0.8 μCuries per well <sup>33</sup>P-γ-ATP [2000-3000 Ci/mmol]. Assay conditions vary slightly for each protein kinase, for example, insulin receptor kinase requires 10 mM MnCl<sub>2</sub> for activity and Calmodulin-dependent protein kinase requires calmodulin and 2 mM CaCl<sub>2</sub>. The reaction mixture was dispensed into the wells of a streptavidin coated Flashplate and 1 μl drug stock in 100% DMSO was added to a 100 μl reaction volume resulting in a final concentration of 1% DMSO in the reaction. Enzyme was diluted in 50 mM Tris-HCl pH=8.0, 0.1% BSA and added to each well. The reaction was incubated for one hour at 30°C in the presence of compound. After one hour the reaction mix was aspirated from the plate and the plate was washed with PBS containing 100 mM EDTA. The plate was read on a scintillation counter to determine <sup>33</sup>P-γ-ATP incorporated into the immobilized peptide. Test compounds were assayed in duplicate at 8 concentrations [100 μM, 10 μM, 1 μM, 100 nM, 10 nM, 1 nM, 100 pM, 10 pM]. A maximum and minimum signal for the assay was determined on each plate. The IC<sub>50</sub> was calculated from the dose response curve of the percent inhibition of the maximum signal in the assay according to the formula [max signal – background/test compound signal – background (100) = % inhibition] by graphing the percent inhibition against the log concentration of test compound. Known inhibitor compounds appropriate for the kinase being assayed were also included on each plate.

Definition and Source of Kinase Enzymes.

VEGF-R (vascular endothelial growth factor receptor-2) is a fusion protein containing a polyhistidine tag at the N-terminus followed by amino acids 786-1343 of the rat VEGF-R2 kinase domain (GenBank Accession #U93306).

CDK1 (cyclin dependent kinase 1) is isolated from insect cells expressing both the human CDK1 catalytic subunit and its positive regulatory subunit cyclin B (New England Biolabs, Beverly, MA, Cat. #6020). CDK4 (cyclin dependent kinase 4) contains amino acids 769 to 921 of the mouse R6 protein found in the

5 GST-retinoblastoma protein construct (Santa Cruz Biotechnology, Santa Cruz, CA; Cat. #SC-4112). Insulin Receptor Kinase consists of residues 941-1313 of the cytoplasmic domain of the beta-subunit of the human insulin receptor (BIOMOL, Plymouth Meeting, PA, Cat. #SE-195). Protein Kinase A is the catalytic subunit of cAMP dependent protein kinase-A purified from bovine

10 heart (Upstate Biotech, Lake Placid, NY, Cat#14-114). PKC (protein kinase-C) is the gamma or beta isoform of the human protein produced in insect cells (BIOMOL, Plymouth Meeting, PA, Cat. #SE-143). Casein Kinase 1 is a truncation at amino acid 318 of the C-terminal portion of the rat CK1 delta isoform produced in *E.coli* (New England Biolabs, Beverly, MA, Cat. #6030).

15 Casein Kinase 2 includes the alpha and beta subunits of the human CK2 protein produced in *E.coli* (New England Biolabs, Beverly, MA, Cat. #6010). Calmodulin Kinase (calmodulin-dependent protein kinase 2) is a truncated version of the alpha subunit of the rat protein produced in insect cells (New England Biolabs, Beverly, MA, Cat. #6060). Glycogen Synthase Kinase-3 is the

20 beta isoform of the rabbit enzyme produced in *E.coli* (New England Biolabs, Beverly, MA, Cat. #6040). MAP Kinase is the rat ERK-2 isoform containing a polyhistidine tag at the N-terminus produced in *E.coli*. and activated by phosphorylation with MEK1 prior to purification (BIOMOL, Plymouth Meeting, PA, Cat. #SE-137). EGFR (epidermal growth factor receptor) is purified from

25 human A431 cell membranes (Sigma, St. Louis, MO, Cat.# E3641). PDGF-R (platelet derived growth factor receptor) is a fusion protein containing a polyhistidine tag at the N-terminus followed by nucleotides 1874-3507 of the human PDGF-R beta subunit kinase domain (Accession #M21616).

30 Peptide Substrates

Assay/ Seq ID NO:	Kinase	Peptide Substrate
1 / 1	VEGF-R	(Biotin)KHKKLAEGSAYEEV-Amide



2 / 2	CDK1	(Biotin)KTPKKAKKPKTPKKAKKL-Amide
3 /	CDK4	GST-Retinoblastoma protein construct
4 / 3	EGF-R	(Biotin)DRVYIHPF-Amide
5 / 4	Protein Kinase A	(Biotin)GRTGRRNSI-Amide
6 / 5	PKC- $\gamma$	(Biotin)RFARKGSLRQKNV-NH <sub>2</sub>
7 / 5	PKC- $\beta$ 2	(Biotin)RFARKGSLRQKNV-NH <sub>2</sub>
8 / 6	Casein Kinase 1	(Biotin)KRRRALS(phospho)VASLPGL-Amide
9 / 7	Casein Kinase 2	(Biotin)RREEETEEE-Amide
10 / 8	Calmodulin Kinase	Biotin)KKALRRQETVDAL-Amide
11 / 9	GSK-3	Biotin)KRREILSRRP(phospho)SYR-Amide
12 / 10	MAP Kinase ERK-2	(Biotin)APRTPGRR-Amide
13 / 11	Insulin Kinase	(Biotin)TRDIYETDYYRK-Amide
14 / 12	PDGF-R	(Biotin)KHKKLAEGSAYEEV-Amide
15	FGF-R2	(Biotin)Poly(GT) 4:1
16	HER2	(Biotin) Poly(GT) 4:1

The IC<sub>50</sub> data (in  $\mu$ M) for various kinases is shown in Table 4. IC<sub>50</sub> values listed as >10 or >100 indicate no observed 50% inhibition at the highest dose tested, nor was an inhibition maxima observed. Values shown as ~10 indicate an approximate value based on an observed 50% inhibition. ND means not tested.

**Table 4**  
**Kinase Selectivity of Pyrazine Derivatives**

Assay	Cmd 4	Cmd 32	Cmd 33	Cmd 35	Cmd 39	Cmd 71	Cmd 72
1	0.042	0.059	0.07	0.094	2.5	0.052	0.089
2	>10	>100	>10	>10	34.8	>100	>100
3	10	>10	10	10	ND	ND	ND
4	1.36	>7.4	17.25	20.7	6.06	>100	>100
5	>100	>100	>100	>100	>100	>100	>100
6	>100	>100	3.96	14.49	>100	ND	ND
7	>100	>100	>100	>100	>100	ND	ND
8	>100	>100	>100	>100	>100	>100	>100
9	>100	>100	>100	>100	10	>100	>100
10	>100	>100	>100	>100	>100	4.89	>100
11	0.478	4.02	11.38	8.15	0.866	0.159	0.318
12	>100	>100	>100	>100	>100	>100	>100
13	1.69	>100	>100	>100	1.8	>100	>100

14	0.36	2.8	29.2	2.5	2.8	1	0.876
15	0.207	2.36	1.4	3.07	1.8	0.317	0.293
16	ND	ND	ND	ND	ND	>100	9.7

Table 4 (cont.)

Kinase Selectivity of Pyrazine Derivatives						
Assay	Cmd 73	Cmd 75	Cmd 76	Cmd 77	Cmd 84	Cmd 85
1	0.105	0.079	0.052	0.03	0.125	0.085
2	6.1	>100	>100	10	2.03	>10
3	ND	ND	ND	ND	ND	ND
4	>100	ND	ND	ND	ND	ND
5	>100	>100	>100	ND	ND	ND
6	1.36	ND	ND	ND	ND	ND
7	1.75	ND	ND	ND	ND	ND
8	5.03	5.6	6.5	ND	ND	ND
9	6.35	8.1	7.2	ND	ND	ND
10	7.55	27	15.8	ND	ND	ND
11	0.491	0.606	0.196	ND	ND	ND
12	>100	>100	>100	ND	ND	ND
13	>100	>100	>100	ND	ND	ND
14	0.175	1.7	0.725	ND	ND	ND
15	0.276	0.326	0.153	0.221	ND	ND
16	7.2	3	2.24	0.966	ND	ND

## EXAMPLE 120

*Cell Proliferation Assay*

- 5           The ability of a test compound to inhibit the proliferation of cell growth was determined by measuring incorporation of <sup>14</sup>C-labelled thymidine into newly synthesized DNA within the cells. This method was used on cell lines derived from carcinomas originating from several tissues such as HeLa cervical adenocarcinoma (American Type Culture Collection (ATCC), Virginia, Cat.
- 10 #CCL-2), A375 malignant melanoma (ATCC CRL-1619), SK-OV-3 ovarian adenocarcinoma (ATCC HTB-77) HCT-116 colon carcinoma (CCL-247) and PC-3 prostate adenocarcinoma (ATCC CRL-1435). The method was also used on primary cells such as HUVEC endothelial cells (ATCC CRL-1730). In this way the effect of a compound on cell growth of cells with many different
- 15 phenotypes can be determined. Cells were trypsinized and counted and 3000-

8000 cells were added to each well of a 96-well CytoStar tissue culture treated scintillating microplate (Amersham #RPNQ0160) in complete medium in a volume of 100  $\mu$ l. Cells were incubated for 24 hours in complete medium at 37°C in an atmosphere containing 5% CO<sub>2</sub>.

5

Next, 1  $\mu$ l of test compound in 100% DMSO was added to the wells of the plate. DMSO only was added to control wells. Cells were incubated for 24 more hours in complete medium at 37°C in an atmosphere containing 5% CO<sub>2</sub>. Methyl <sup>14</sup>C-thymidine 56 mCi/mmol (NEN #NEC568 or Amersham #CFA532) was diluted in complete medium and 0.2  $\mu$ Ci/well was added to each well of the CytoStar plate in a volume of 20  $\mu$ l. The plate was incubated for 24 hours at 37°C plus 5% CO<sub>2</sub> in drug plus <sup>14</sup>C-thymidine.

10

The contents of the plate were discarded into a <sup>14</sup>C radioactive waste container by inverting the plate and the plate was washed twice with 200  $\mu$ l PBS. 200  $\mu$ l of PBS is then added to each well. The top of the plate was sealed with a transparent plate sealer and a white plate backing sealer (Packard #6005199) was applied to the bottom of the plate. The degree of Methyl <sup>14</sup>C-thymidine incorporation was quantified on a Packard Top Count.

20

The IC<sub>50</sub> data (in  $\mu$ M) for various compounds is shown in Table 5. IC<sub>50</sub> values listed as >10 or >100 indicate no observed 50% inhibition at the highest dose tested. ND means not tested.

Table 5

## Inhibition of cell proliferation

Cell line	Cmd 4	Cmd 32	Cmd 33	Cmd 35	Cmd 71
HeLa	4.56	86.4	2.23	>100	3.8
HCT-116	8.35	23.47	>100	>100	3.29
SK-OV-3	3	14.57	21.47	19.34	ND
MDA-MB-231	3.26	27.62	12.67	98.3	1.88
PC-3	11.34	67.64	22.87	>100	3.2

Table 5 (cont.)

## Inhibition of cell proliferation

Cell line	Cmd 72	Cmd 73	Cmd 75	Cmd 76
-----------	--------	--------	--------	--------

<b>HeLa</b>	5.7	2.2	12.5	4.94
<b>HCT-116</b>	4.97	ND	ND	ND
<b>SK-OV-3</b>	ND	3.78	>10	12.9
<b>MDA-MB-231</b>	2.57	ND	ND	ND
<b>PC-3</b>	2.58	ND	5.34	ND

## EXAMPLE 121

*Rat Aortic Ring Assay*

The rat aortic ring assay is a rapid *in vitro* assay that measures new capillary growth in an environment that closely approximates the *in vivo* conditions of the extracellular matrix. The assay was performed as described (Nicosia, RF and Ottinetti, A. Growth of new microvessels in serum-free matrix culture of rat aorta. *Lab Invest.*, 63: 115-122, 1990). Thoracic aortas were removed from 1 to 2-month old male Sprague-Dawley rats and transferred to a culture dish containing serum-free MCDB 131 medium (Clonetics). Extraneous tissue was removed and the aorta was sectioned into rings approximately 1mm long and rinsed 8-10 times in serum-free medium. A solution of sterile 1.5% agarose (Type VI-A, Sigma, St. Louis, MO) was added to the wells of a 6-well plate. The wells were filled with clotting fibrinogen solution and an aortic ring was transferred into the well positioned with the lumen oriented horizontally in the center of the fibrin gel solution. The fibrinogen solution was prepared in MCDB 131 medium with bovine fibrinogen at 3 mg/ml. Clotting was initiated by adding 20  $\mu$ l of a 50 NIH units/ml bovine thrombin solution and the fibrin gel generally formed within 30 seconds. The fibrinolytic inhibitor amino-n-caproic acid was added to the culture medium at 300 $\mu$ g/ml (microgram per milliliter) for the first four days of the assay and at 50  $\mu$ g/ml from day 5 to day 8. Once the fibrin gel solution solidified, 5 ml of serum-free MCDB 131 media containing 100  $\mu$ g/ml penicillin, 100  $\mu$ g/ml streptomycin and 0.25  $\mu$ g/ml amphotericin B was added to each well. Explants were incubated at 37°C with 5% CO<sub>2</sub> for 8 days. Medium was replaced every 2-3 days and the assay was analyzed on day 8. Inhibition of vascular sprouting was measured by adding test compounds diluted in DMSO. The final concentration of DMSO in the assay did not exceed 0.2%. As shown in Table 6, the degree of inhibition was quantified using the Vessels image analysis package as described (Nissanov, J, Tuman, RW, Gruver,

LM and Fortunato, JM. Automatic vessel segmentation and quantification of the rat aortic ring assay of angiogenesis. *Lab. Invest.* 73, 734-739, 1995).

**Table 6 – Inhibition of Vascular Sprouting**

	<b>Cmd 4</b>	<b>Cmd 32</b>	<b>Cmd 33</b>	<b>Cmd 35</b>
<b>(IC<sub>50</sub> <math>\mu</math>M)</b>	0.099	0.83	>1	>1

5

## EXAMPLE 122

*In vitro* AUTOPHOSPHORYLATION assay for kinase inhibition

*VEGF-R autophosphorylation assay*

Growth factor receptors are activated following binding of their cognate ligands which catalyzes autophosphorylation of the receptor. The VEGF receptor is autophosphorylated upon binding to VEGF (Tessler, S., Rockwell, P., Hicklin, D., Cohen, T., Levi, B.-Z., Witte, L. Lemischka, I.R. & Neufeld, G. (1994) *J. Biol. Chem.* 269, 12456-12461) and activation of signal transduction then occurs (Heldin, C.-H. (1995) *Cell* 80, 213-223). As autophosphorylation is essential for a signal to be transduced, an assay to quantitate the degree of phosphorylation of the VEGF receptor measures the ability of a test compound to directly inhibit activation of the VEGF-R and eliminates the possibility of substrate interactions.

A kinase reaction mixture is prepared containing 50 mM Tris-HCl pH=8, 10 mM MgCl<sub>2</sub>, 0.1 mM Na<sub>3</sub>VO<sub>4</sub>, 1 mM DTT, 5-10  $\mu$ M ATP, and 0.8  $\mu$ Curies per well <sup>33</sup>P- $\gamma$ -ATP [2000-3000 Ci/mmol]. 70  $\mu$ l of the kinase reaction mixture is dispensed into the well of an NTA-Nickel coated FlashPlate™ (Cat. # SMP107, NEN, Boston, MA). Then 1  $\mu$ l of test compound in 100% DMSO is added to the wells resulting in a final concentration of 1% DMSO in the reaction (100  $\mu$ l final reaction volume includes subsequent enzyme solution). Then soluble rat tyrosine kinase containing an N-terminal 6XHIS tag is diluted in 50 mM Tris-HCl pH=8.0, 0.1% BSA at a concentration of 5 ng per microliter and 30  $\mu$ l (150ng per test well) is added to each well to initiate the reaction. The reaction is incubated for one hour at 30°C. At the end of the 1-hour incubation, the reaction is terminated by aspirating the reaction mixture from the plate and

washing the wells twice with PBS containing 100 mM EDTA. The 6XHIS-VEGF receptor becomes immobilized on the Flashplate™ and the incorporation of <sup>33</sup>P-γ-ATP via autophosphorylation is measured by reading the plate on a scintillation counter. Inhibition of the enzymatic activity of the VEGF-R is  
5 measured by observing a reduced amount of <sup>33</sup>P-γ-ATP incorporated into the immobilized enzyme.

### EXAMPLE 123

#### *In vivo models – Inhibition of Tumor Growth*

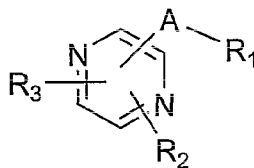
10 The *in vivo* effect of a compound on the growth of human tumor cells can be evaluated by implanting human tumor cells into the hindflank of athymic mice and administering test compound to the mice. Such assays are useful in identifying and confirming compounds that are useful for inhibiting angiogenesis or to identify compounds that can inhibit VEGF activity and therefor are useful  
15 for treating a variety of cancers or other diseases associated with abnormal or aberrant angiogenesis, such as those diseases discussed *supra*. Human tumor cells originating from a variety of different cancer types, such as A375 human melanoma cells, were implanted subcutaneously into the hindflank of male athymic mice (Charles River) and allowed to establish a sizeable tumor for 6-10  
20 days as determined by caliper measurements. Test compound was then administered by injecting the compound formulated in an appropriate vehicle, here saline was used as the vehicle, intraperitoneally into the mice once a day for 30 days. The test compound can also be administered by other routes such as orally, sub cutaneously or by intravenous infusion. The size of the tumor in this  
25 study was measured every four days and the degree of inhibition was determined by comparing drug-treated animals to animals that were injected with vehicle only. Figure 1 illustrates the results of one study with **Cmd 33** indicating a delay of tumor size progression. Similarly the compounds of this invention can be tested in other known models of aberrant angiogenesis, such as models of  
30 retinopathy, endometriosis, psoriasis and the like.

The synergistic action or enhancement of conventional chemotherapeutic agent by a test compound can also be determined with this model by comparing animals treated with the standard therapy alone to animals treated with test

compound plus the same standard therapy. An additive effect on the delay of tumor growth will be observed if synergistic action due to test compound is occurring.

## WHAT IS CLAIMED IS:

1. A compound of Formula 1:



Formula 1

- 5 or a pharmaceutically acceptable salt thereof, wherein

$R_1$  is selected from the group consisting of cycloalkyl, heterocyclyl, biheterocyclyl, aryl, biaryl, heteroaryl and biheteroaryl optionally substituted with 1 to 5 substituents independently selected from the group consisting of

10 alkyl, lower alkyl, alkenyl, alkynyl, alkoxy, lower alkoxy, heterocyclyl, heterocyclylalkyl, heterocyclylalkenyl, heterocyclylalkynyl, heterocyclylalkoxy, aryl, arylalkyl, arylalkenyl, arylalkynyl, arylalkoxy, heteroaryl, heteroarylalkyl, heteroarylalkenyl, heteroarylalkynyl, heteroarylalkoxy, OH, hydroxyalkyl, halogen, cyano, nitro, amino,

15 alkylamino, alkylaminoalkyl, alkylaminoalkylamino, aminoalkyl, aminoalkylamino, di(alkyl)amino, di(alkyl)aminoalkyl, di(alkyl)aminoalkylamino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, carbamoyl, acyl, acylalkyl, alkoxycarbonyl, alkoxycarbonylalkyl, acylamino, alkylsulfonyl, alkylsulfonylamino, arylsulfonylamino (wherein aryl is

20 substituted with 1 to 3 substituents independently selected from the group consisting of cyano, halogen, hydroxy, nitro, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy), aminosulfonyl, aminosulfonylalkyl, alkylaminosulfonyl, alkylaminosulfonylalkyl, di(alkyl)aminosulfonyl, di(alkyl)aminosulfonylalkyl, carboxyl, (hydroxyalkyl)carbonyl,

25 (hydroxyalkoxy)carbonyl, trihalo substituted lower alkyl and trihalo substituted lower alkoxy;

A is selected from the group consisting of  $-N(R_4)(CH_2)_x-$ ,  $-O(CH_2)_x-$ ,  $-S(CH_2)_x-$ ,  $-SO_2(CH_2)_x-$ ,  $-SO_2N(CH_2)_x-$ ,  $-NSO_2(CH_2)_x-$ ,  $-N(R_4)(CH_2)_{1-4}O(CH_2)_x-$ ,

30  $-N(R_4)(CH_2)_{1-4}NH(CH_2)_x-$ ,  $-N(R_4)CONH(CH_2)_x-$  and  $-N(R_4)CNNH(CH_2)_x-$ ; wherein x is an integer from 0 to 4;



- $R_4$  is selected from the group consisting of H, lower alkyl, alkyl, hydroxyalkyl, alkoxyalkyl, arylalkyl, lower alkenyl, alkenyl, aryl and heteroaryl; wherein aryl and heteroaryl are optionally substituted with 1 to 5 substituents
- 5 independently selected from the group consisting of OH, halogen, cyano, nitro, amino, alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, alkyl, lower alkyl, alkoxy, lower alkoxy, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy;
- 10  $R_2$  is selected from the group consisting of heteroaryl and biheteroaryl optionally substituted with 1 to 2 substituents independently selected from  $R_7$  and 1 substituent selected from  $R_8$ ;
- $R_7$  is selected from the group consisting of alkyl, lower alkyl, alkoxy, lower
- 15 alkoxy, alkenyl, alkynyl, heterocyclyl, heterocyclylalkyl, heterocyclylalkoxy, aryl, arylalkyl, arylalkoxy, OH, hydroxyalkyl, halogen, cyano, nitro, amino, alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, carbamoyl, acyl, acylalkyl, alkoxycarbonyl, alkoxycarbonylalkyl, acylamino, alkylsulfonyl, alkylsulfonylamino, arylsulfonylamino (wherein aryl is
- 20 substituted with 1 to 3 substituents independently selected from the group consisting of cyano, halogen, hydroxy, nitro, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy), carboxyl, (hydroxyalkyl)carbonyl, (hydroxyalkoxy)carbonyl, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy;
- 25  $R_8$  is selected from the group consisting of alkyl, OH, hydroxyalkyl, halogen, cyano, amino, alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, carbamoyl, alkylcarbonylamino, alkylcarbonyl, alkoxycarbonyl, (hydroxyalkyl)carbonyl, (hydroxyalkoxy)carbonyl,
- 30  $O(CH_2)_nR_5$ ,  $O(CH_2)_nO(CH_2)_mR_5$ ,  $O(CH_2)_nCH[(CH_2)_mR_5]_2$ ,  $O(CH_2)_nN[(CH_2)_mR_5]_2$ ,  $OCON[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nR_5$ ,  $NH(CH_2)_nCH(R_5)_2$ ,  $NH(CH_2)_nSO_2(CH_2)_mR_5$ ,  $NH(CH_2)_nO(CH_2)_mR_5$ ,  $NH(CH_2)_nOCH[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nO(CH_2)_mO(CH_2)_mR_5$ ,  $NH(CH_2)_nN[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nSO_2NH(CH_2)_mR_5$ ,  $NH(CH_2)_nCH(OH)(CH_2)_mR_5$ ,

$\text{NH}(\text{CH}_2)_n\text{CH}(\text{OH})(\text{CH}_2)_m\text{OR}_5$ ,  $\text{NH}(\text{CH}_2)_n\text{CH}(\text{OH})(\text{CH}_2)_m\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ,

$\text{NH}(\text{CH}_2)_n\text{CO}(\text{CH}_2)_m\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_n\text{CO}_2(\text{CH}_2)_m\text{R}_5$ ,

$\text{NH}(\text{CH}_2)_n\text{CO}(\text{CH}_2)_m\text{SO}_2\text{NH}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{CH}(\text{R}_5)_2$ ,

$\text{NHCO}(\text{CH}_2)_n\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$ ,

5  $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{O}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{CO}(\text{CH}_2)_m\text{R}_5$ ,

$\text{NHCO}(\text{CH}_2)_n\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{CONH}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$ , and

$\text{CONH}(\text{CH}_2)_n\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ; wherein n is an integer from 0 to 6 and m is an integer from 0 to 4; with the proviso, that m is at least 1 when  $\text{R}_5$  is selected from the group consisting of OH, amino, alkylamino and di(alkyl)amino;

10

$\text{R}_5$  is selected from the group consisting of H, OH, lower alkyl, amino,

alkylamino, di(alkyl)amino, aryl, heteroaryl, biheteroaryl and heterocyclyl;

wherein aryl, heteroaryl and heterocyclyl are optionally substituted with 1 to 3 substituents independently selected from the group consisting of alkyl,

15

lower alkyl, acyl, carboxyl, aryl (optionally substituted with 1 to 5 halogen substituents), OH, halogen, cyano, amino, alkylamino, di(alkyl)amino,

(hydroxyalkyl)amino, di(hydroxyalkyl)amino, alkylsulfonyl, aminosulfonyl, alkylaminosulfonyl and aminosulfonylalkyl; and, wherein heterocyclyl is

further optionally substituted with 1 to 3 oxo substituents; and,

20

$\text{R}_3$  is selected from the group consisting of H, alkyl, lower alkyl, alkoxy, lower alkoxy, alkenyl, alkynyl, heterocyclyl, heterocyclylalkyl, heterocyclylalkoxy,

aryl, arylalkyl, arylalkoxy, OH, hydroxyalkyl, halogen, cyano, nitro, amino, alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino,

25

carbamoyl, acyl, acylalkyl, alkoxycarbonyl, alkoxycarbonylalkyl, acylamino, alkylsulfonyl, alkylsulfonylamino, arylsulfonylamino (wherein aryl is

substituted with 1 to 3 substituents independently selected from the group consisting of cyano, halogen, hydroxy, nitro, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy), carboxyl, (hydroxyalkyl)carbonyl,

30

(hydroxyalkoxy)carbonyl, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy.

2. The compound of claim 1 wherein  $\text{R}_1$  is selected from the group consisting of cycloalkyl, heterocyclyl, biheterocyclyl, aryl, biaryl,

- heteroaryl and biheteroaryl optionally substituted with 1 to 5 substituents independently selected from the group consisting of alkyl, lower alkyl, alkenyl, alkynyl, alkoxy, lower alkoxy, heterocyclyl, heterocyclalkyl, heterocyclalkoxy, aryl, arylalkyl, arylalkoxy, heteroaryl, heteroarylalkyl, heteroarylalkoxy, OH, hydroxyalkyl, halogen, cyano, nitro, amino, alkylamino, alkylaminoalkyl, alkylaminoalkylamino, aminoalkyl, aminoalkylamino, di(alkyl)amino, di(alkyl)aminoalkyl, di(alkyl)aminoalkylamino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, carbamoyl, acyl, alkoxycarbonyl, aminosulfonyl, aminosulfonylalkyl, alkylaminosulfonyl, alkylaminosulfonylalkyl, di(alkyl)aminosulfonyl, di(alkyl)aminosulfonylalkyl, carboxyl, (hydroxyalkyl)carbonyl, trihalo substituted lower alkyl and trihalo substituted lower alkoxy.
3. The compound of claim 1 wherein  $R_1$  is selected from the group consisting of aryl optionally substituted with 1 to 5 substituents independently selected from the group consisting of lower alkyl, lower alkoxy, heterocyclyl, heterocyclalkyl, aryl, arylalkyl, heteroaryl, heteroarylalkyl, OH, halogen, cyano, amino, alkylamino, alkylaminoalkyl, alkylaminoalkylamino, aminoalkyl, aminoalkylamino, di(alkyl)amino, di(alkyl)aminoalkyl, di(alkyl)aminoalkylamino, carbamoyl, acyl, alkoxycarbonyl, aminosulfonyl, aminosulfonylalkyl, alkylaminosulfonyl, alkylaminosulfonylalkyl, di(alkyl)aminosulfonyl, di(alkyl)aminosulfonylalkyl, carboxyl, trihalo substituted lower alkyl and trihalo substituted lower alkoxy.
4. The compound of claim 1 wherein  $R_1$  is selected from the group consisting of phenyl optionally substituted with 1 to 5 substituents independently selected from the group consisting of lower alkyl, lower alkoxy, OH, halogen, cyano, amino, alkylamino, alkylaminoalkyl, alkylaminoalkylamino, aminoalkyl, aminoalkylamino, di(alkyl)amino, di(alkyl)aminoalkyl, di(alkyl)aminoalkylamino, carbamoyl, acyl, alkoxycarbonyl, aminosulfonyl, aminosulfonylalkyl, alkylaminosulfonyl, alkylaminosulfonylalkyl, di(alkyl)aminosulfonyl, di(alkyl)aminosulfonylalkyl, carboxyl, trihalo substituted lower alkyl and

trihalo substituted lower alkoxy.

5. The compound of claim 1 wherein  $R_1$  is selected from the group consisting of phenyl optionally substituted with 1 to 5 substituents independently selected from the group consisting of methoxy, chlorine and fluorine.  
5
6. The compound of claim 1 wherein A is selected from the group consisting of  $-N(R_4)(CH_2)_x-$ ,  $-O(CH_2)_x-$ ,  $-S(CH_2)_x-$ ,  $-SO_2(CH_2)_x-$ ,  $-SO_2N(CH_2)_x-$ ,  $-NSO_2(CH_2)_x-$ ,  $-N(R_4)(CH_2)_{1-4}O(CH_2)_x-$  and  $-N(R_4)(CH_2)_{1-4}NH(CH_2)_x-$ ; wherein x is an integer from 0 to 3.  
10
7. The compound of claim 1 wherein A is selected from the group consisting of  $-N(R_4)(CH_2)_x-$ ,  $-O(CH_2)_x-$ ,  $-S(CH_2)_x-$ ,  $-SO_2(CH_2)_x-$ ,  $-SO_2N(CH_2)_x-$ ,  $-NSO_2(CH_2)_x-$ ,  $-N(R_4)(CH_2)_{1-4}O(CH_2)_x-$  and  $-N(R_4)(CH_2)_{1-4}NH(CH_2)_x-$ ; wherein x is an integer from 0 to 1.  
15
8. The compound of claim 1 wherein A is selected from the group consisting of  $-N(R_4)(CH_2)_x-$  and  $-O(CH_2)_x-$ ; wherein x is an integer from 0 to 1.  
20
9. The compound of claim 1 wherein  $R_4$  is selected from the group consisting of H, alkyl, lower alkyl, alkoxyalkyl, alkenyl, lower alkenyl, hydroxyalkyl, aryl, arylalkyl and heteroaryl.  
25
10. The compound of claim 1 wherein  $R_4$  is selected from the group consisting of H, lower alkyl and hydroxyalkyl.
11. The compound of claim 1 wherein  $R_4$  is H.  
30
12. The compound of claim 1 wherein  $R_2$  is selected from the group consisting of heteroaryl and biheteroaryl optionally substituted with 1 to 2 substituents independently selected from  $R_7$  and optionally substituted with 1 substituent selected from  $R_8$ ; wherein  $R_7$  is substituted on the 2 or

6 position from the point of attachment of  $R_2$ ; and, wherein  $R_8$  is substituted on a carbon atom at the 4 or 5 position from the point of attachment of  $R_2$ .

- 5     13.     The compound of claim 1 wherein  $R_2$  is selected from the group consisting of heteroaryl optionally substituted with 1 substituent selected from  $R_7$  and substituted with 1 substituent selected from  $R_8$ ; wherein  $R_7$  is substituted on the 2 or 6 position from the point of attachment of  $R_2$ ; and, wherein  $R_8$  is substituted on a carbon atom at the 4 or 5 position  
10     from the point of attachment of  $R_2$ .
14.     The compound of claim 1 wherein  $R_2$  is selected from the group consisting of thienyl, pyrrolyl, oxazolyl, thiazolyl, imidazolyl, pyrazolyl, isoxazolyl, isothiazolyl, pyridinyl, pyridazinyl, pyrimidinyl and pyrazinyl  
15     optionally substituted with 1 substituent selected from  $R_7$  and substituted with 1 substituent selected from  $R_8$ ; wherein  $R_7$  is substituted on the 2 or 6 position from the point of attachment of  $R_2$ ; and, wherein  $R_8$  is substituted on a carbon atom at the 4 or 5 position from the point of attachment of  $R_2$ .
- 20     15.     The compound of claim 1 wherein  $R_2$  is selected from the group consisting of pyridinyl, pyridazinyl, pyrimidinyl and pyrazinyl optionally substituted with 1 substituent selected from  $R_7$  and substituted with 1 substituent selected from  $R_8$ ; wherein  $R_7$  is substituted on the 2 or 6  
25     position from the point of attachment of  $R_2$ ; and, wherein  $R_8$  is substituted on a carbon atom at the 4 or 5 position from the point of attachment of  $R_2$ .
- 30     16.     The compound of claim 1 wherein  $R_7$  is selected from the group consisting of lower alkyl, lower alkoxy, heterocyclalkyl, aryl, arylalkyl, OH, hydroxyalkyl, halogen, cyano, nitro, amino, alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, acyl, carboxyl, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy.

17. The compound of claim 1 wherein  $R_7$  is selected from the group consisting of lower alkyl, OH, halogen, cyano, nitro, amino, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy.
- 5 18. The compound of claim 1 wherein  $R_7$  is selected from the group consisting of methyl, ethyl, OH, bromine, chlorine, fluorine, cyano, nitro, amino, trifluoromethyl and trifluoromethoxy.
- 10 19. The compound of claim 1 wherein  $R_8$  is selected from the group consisting of OH, amino, (hydroxyalkyl)amino, alkoxycarbonyl,  $OCON[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nR_5$ ,  $NH(CH_2)_nCH(R_5)_2$ ,  $NH(CH_2)_nSO_2(CH_2)_mR_5$ ,  $NH(CH_2)_nO(CH_2)_mR_5$ ,  $NH(CH_2)_nOCH[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nO(CH_2)_mO(CH_2)_mR_5$ ,  $NH(CH_2)_nN[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nSO_2NH(CH_2)_mR_5$ ,  $NH(CH_2)_nCH(OH)(CH_2)_mR_5$ ,  $NH(CH_2)_nCH(OH)(CH_2)_mOR_5$ ,  $NH(CH_2)_nCH(OH)(CH_2)_mN[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nCO(CH_2)_mN[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nCO_2(CH_2)_mR_5$ ,  $NH(CH_2)_nCO(CH_2)_mSO_2NH(CH_2)_mR_5$ ,  $NHCO(CH_2)_nR_5$ ,  $NHCO(CH_2)_nO(CH_2)_mR_5$ ,  $NHCO(CH_2)_nO(CH_2)_mO(CH_2)_mR_5$ ,  $NHCO(CH_2)_nO(CH_2)_mCO(CH_2)_mR_5$ ,  $CONH(CH_2)_nO(CH_2)_mR_5$  and  $CONH(CH_2)_nN[(CH_2)_mR_5]_2$ ; wherein  $n$  is an integer from 0 to 6 and  $m$  is an integer from 0 to 4; with the proviso, that  $m$  is at least 1 when  $R_5$  is selected from the group consisting of OH, amino, alkylamino and di(alkyl)amino.
- 15 20. The compound of claim 1 wherein  $R_8$  is selected from the group consisting of OH, amino, (hydroxyalkyl)amino, alkoxycarbonyl,  $OCON[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nR_5$ ,  $NH(CH_2)_nCH(R_5)_2$ ,  $NH(CH_2)_nSO_2(CH_2)_mR_5$ ,  $NH(CH_2)_nO(CH_2)_mR_5$ ,  $NH(CH_2)_nOCH[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nO(CH_2)_mO(CH_2)_mR_5$ ,  $NH(CH_2)_nN[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nSO_2NH(CH_2)_mR_5$ ,  $NH(CH_2)_nCH(OH)(CH_2)_mR_5$ ,  $NH(CH_2)_nCH(OH)(CH_2)_mOR_5$ ,  $NH(CH_2)_nCH(OH)(CH_2)_mN[(CH_2)_mR_5]_2$ ,
- 20 25 30

- $\text{NH}(\text{CH}_2)_n\text{CO}(\text{CH}_2)_m\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_n\text{CO}_2(\text{CH}_2)_m\text{R}_5$ ,  
 $\text{NH}(\text{CH}_2)_n\text{CO}(\text{CH}_2)_m\text{SO}_2\text{NH}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{R}_5$ ,  
 $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{O}(\text{CH}_2)_m\text{R}_5$ ,  
 $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{CO}(\text{CH}_2)_m\text{R}_5$ ,  $\text{CONH}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$  and  
 5  $\text{CONH}(\text{CH}_2)_n\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ; wherein  $n$  is an integer from 0 to 5 and  $m$  is  
 an integer from 0 to 2; with the proviso, that  $m$  is at least 1 when  $\text{R}_5$  is  
 selected from the group consisting of OH, amino, alkylamino and  
 di(alkyl)amino.
- 10 21. The compound of claim 1 wherein  $\text{R}_8$  is selected from the group  
 consisting of OH, amino, (2-hydroxyethyl)amino,  
 (3-hydroxy-*n*-propyl)amino, (4-hydroxy-*n*-butyl)amino, ethoxycarbonyl,  
 $\text{OCON}(\text{R}_5)_2$ ,  $\text{NH}(\text{CH}_2)_{1-4}\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_{1-3}\text{SO}_2(\text{CH}_2)_{0-1}\text{R}_5$ ,  
 $\text{NH}(\text{CH}_2)_{1-3}\text{O}(\text{CH}_2)_{0-1}\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_{1-4}\text{OCH}[(\text{CH}_2)_{1-2}\text{R}_5]_2$ ,  
 15  $\text{NH}(\text{CH}_2)_{1-3}\text{O}(\text{CH}_2)_{1-2}\text{O}(\text{CH}_2)_{1-2}\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_{1-4}\text{N}[(\text{CH}_2)_{0-2}\text{R}_5]_2$ ,  
 $\text{NH}(\text{CH}_2)_{1-4}\text{SO}_2\text{NH}(\text{CH}_2)_{1-2}\text{R}_5$ ,  $\text{NH}(\text{CH}_2)_{1-4}\text{CH}(\text{OH})(\text{CH}_2)_{1-2}\text{R}_5$ ,  
 $\text{NH}(\text{CH}_2)_{1-4}\text{CH}(\text{OH})(\text{CH}_2)_{1-2}\text{OR}_5$ ,  
 $\text{NH}(\text{CH}_2)_{1-4}\text{CH}(\text{OH})(\text{CH}_2)_{1-2}\text{N}[(\text{CH}_2)_{0-1}\text{R}_5]_2$ ,  
 $\text{NH}(\text{CH}_2)_{1-3}\text{CO}(\text{CH}_2)_{0-1}\text{N}[(\text{CH}_2)_{0-1}\text{R}_5]_2$ ,  $\text{NH}(\text{CH}_2)_{1-3}\text{CO}_2(\text{CH}_2)_{0-1}\text{R}_5$ ,  
 20  $\text{NH}(\text{CH}_2)_{1-4}\text{CO}(\text{CH}_2)_{1-2}\text{SO}_2\text{NH}(\text{CH}_2)_{1-2}\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_{0-1}\text{R}_5$ ,  
 $\text{NHCO}(\text{CH}_2)_{1-3}\text{O}(\text{CH}_2)_{0-2}\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_{1-2}\text{O}(\text{CH}_2)_{1-2}\text{O}(\text{CH}_2)_{1-2}\text{R}_5$ ,  
 $\text{NHCO}(\text{CH}_2)_{1-2}\text{O}(\text{CH}_2)_{0-1}\text{CO}(\text{CH}_2)_{1-2}\text{R}_5$ ,  $\text{CONH}(\text{CH}_2)_{1-3}\text{O}(\text{CH}_2)_{0-2}\text{R}_5$  and  
 $\text{CONH}(\text{CH}_2)_{1-3}\text{N}[(\text{CH}_2)_{1-2}\text{R}_5]_2$ ; with the proviso, that the  $\text{R}_5$  alkylene  
 linking group is at least methylene when  $\text{R}_5$  is selected from the group  
 25 consisting of OH, amino, alkylamino and di(alkyl)amino.
22. The compound of claim 1 wherein  $\text{R}_5$  is selected from the group  
 consisting of H, OH, lower alkyl, amino, alkylamino, di(alkyl)amino,  
 aryl, heteroaryl and heterocyclyl; wherein aryl, heteroaryl and  
 30 heterocyclyl are optionally substituted with 1 to 3 substituents  
 independently selected from the group consisting of lower alkyl, acyl,  
 carboxyl, aryl (optionally substituted with one halogen substituent),  
 di(alkyl)amino; alkylsulfonyl, aminosulfonyl, alkylaminosulfonyl and  
 aminosulfonylalkyl; and, wherein heterocyclyl is further optionally

substituted with 1 to 3 oxo substituents.

23. The compound of claim 1 wherein R<sub>5</sub> is selected from the group consisting of H, OH, lower alkyl, heteroaryl and heterocyclyl; wherein heterocyclyl is optionally substituted with 1 to 3 substituents independently selected from the group consisting of lower alkyl, acyl, carboxyl, aryl (optionally substituted with one halogen substituent), di(alkyl)amino, alkylsulfonyl, aminosulfonyl, alkylaminosulfonyl, aminosulfonylalkyl and oxo.
24. The compound of claim 1 wherein R<sub>5</sub> is selected from the group consisting of H, OH, methyl, ethyl, *t*-butyl, 1*H*-azetidiny, 1*H*-pyrrolidiny, 4-tetrahydro-2*H*-pyrany, hexahydro-1*H*-azepiny, 1,3-dioxolany, 1,3-dioxany, piperidiny, piperaziny, imidazolyl, pyrazolyl, triazolyl and pyridiny; wherein 1,3-dioxolany, 1,3-dioxany, piperaziny and piperidiny are optionally substituted with 1 to 2 substituents independently selected from the group consisting of methyl, acetyl, carboxyl, phenyl (optionally substituted with chlorine), di(methyl)amino, methylsulfonyl, methylaminosulfonyl and oxo.
25. The compound of claim 1 wherein R<sub>3</sub> is selected from the group consisting of H, lower alkyl, lower alkoxy, OH, halogen, cyano, amino, alkylamino and di(alkyl)amino.
26. The compound of claim 1 wherein R<sub>3</sub> is selected from the group consisting of H, lower alkyl, lower alkoxy, OH, halogen, amino and di(alkyl)amino.
27. The compound of claim 1 wherein R<sub>3</sub> is selected from the group consisting of H and methyl.
28. A compound selected from the group consisting of:  
3-[[5-[6-[(3-chlorophenyl)amino]pyraziny]-3-pyridiny]amino]-1-propanol;  
3-[[5-[2-[(3-chlorophenyl)amino]-6-methyl-4-pyrimidiny]-3-pyridiny]amino]-1-



propanol;

2-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]-ethanol;

4-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-butanol;

3-[[5-[6-[(3-fluorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-propanol;

3-[[5-[6-[(3-methoxyphenyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-propanol;

3-[[5-[6-[(phenylmethyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-propanol;

3-[[6'-[(3-chlorophenyl)amino][2,2'-bipyrazin]-6-yl]amino]-1-propanol;

3-[[4-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]-1-propanol;

3-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-2-thiazolyl]amino]-1-propanol;

and,

2-[2-[2-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]ethoxy]ethoxy]-ethanol.

29. A compound selected from the group consisting of:

6-(5-amino-3-pyridinyl)-*N*-(3-chlorophenyl)-2-pyrazinamine;

*N*<sup>1</sup>-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-*N*<sup>2</sup>,*N*<sup>2</sup>-dimethyl-1,2-ethanediamine;

*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-4-morpholinepropanamine;

*N*<sup>1</sup>-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-*N*<sup>3</sup>,*N*<sup>3</sup>-dimethyl-1,3-propanediamine;

*N*-(3-chlorophenyl)-6-[5-[[3-(1-piperazinyl)propyl]amino]-3-pyridinyl]-2-pyrazinamine;

*N*-(3-chlorophenyl)-6-[5-[[4-(4-pyridinyl)butyl]amino]-3-pyridinyl]-2-pyrazinamine;

*N*-(3-chlorophenyl)-6-[5-[[3-(4-pyridinyl)propyl]amino]-3-pyridinyl]-2-pyrazinamine;

*N*-(3-chlorophenyl)-6-[5-[[3-(3-pyridinyl)propyl]amino]-3-pyridinyl]-2-pyrazinamine;

*N*-(3-chlorophenyl)-6-[5-[[3-(1*H*-pyrazol-1-yl)propyl]amino]-3-pyridinyl]-2-pyrazinamine;

*N*-(3-chlorophenyl)-6-[5-[[3-(1*H*-1,2,4-triazol-1-yl)propyl]amino]-3-pyridinyl]-2-pyrazinamine;

*N*-(3-chlorophenyl)-6-[5-[[3-(1*H*-imidazol-1-yl)propyl]amino]-3-pyridinyl]-2-pyrazinamine;

*N*-(3-chlorophenyl)-6-[5-[[3-(tetrahydro-2*H*-pyran-4-yl)methyl]amino]-3-pyridinyl]-2-pyrazinamine;

*N*-(3-chlorophenyl)-6-[5-[[2-(2-methoxyethoxy)ethyl]amino]-3-pyridinyl]-2-pyrazinamine;

*N*-(4-methoxyphenyl)-6-[5-[[3-(4-pyridinyl)propyl]amino]-3-pyridinyl]-2-pyrazinamine;

*N*-(3,4-dichlorophenyl)-6-[5-[[3-(4-pyridinyl)propyl]amino]-3-pyridinyl]-2-pyrazinamine;

*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-2-(2-methoxyethoxy)-acetamide;

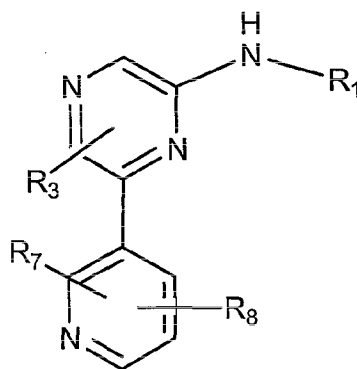
*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-2-ethoxy-acetamide;

*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-3-methoxy-propanamide;  
and,  
*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-2-hydroxy-acetamide.

30. A compound selected from the group consisting of:

*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-2-methoxy-acetamide;  
*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-3-pyridinecarboxamide;  
*N*-[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]-1-pyrrolidinecarboxamide;  
and,  
4-[[5-[6-[(3-chlorophenyl)amino]pyrazinyl]-3-pyridinyl]amino]-butanoic acid ethyl ester.

31. A compound of Formula 2:



Formula 2

or a pharmaceutically acceptable salt thereof, wherein

R<sub>1</sub> is selected from the group consisting of cycloalkyl, heterocyclyl,

- 10 biheterocyclyl, aryl, biaryl, heteroaryl and biheteroaryl optionally substituted with 1 to 5 substituents independently selected from the group consisting of alkyl, lower alkyl, alkenyl, alkynyl, alkoxy, lower alkoxy, heterocyclyl, heterocyclylalkyl, heterocyclylalkenyl, heterocyclylalkynyl, heterocyclylalkoxy, aryl, arylalkyl, arylalkenyl, arylalkynyl, arylalkoxy, 15 heteroaryl, heteroarylalkyl, heteroarylalkenyl, heteroarylalkynyl, heteroarylalkoxy, OH, hydroxyalkyl, halogen, cyano, nitro, amino, alkylamino, alkylaminoalkyl, alkylaminoalkylamino, aminoalkyl, aminoalkylamino, di(alkyl)amino, di(alkyl)aminoalkyl, di(alkyl)aminoalkylamino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, 20 carbamoyl, acyl, acylalkyl, alkoxycarbonyl, alkoxycarbonylalkyl, acylamino,

- alkylsulfonyl, alkylsulfonylamino, arylsulfonylamino (wherein aryl is substituted with 1 to 3 substituents independently selected from the group consisting of cyano, halogen, hydroxy, nitro, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy), aminosulfonyl, aminosulfonylalkyl, 5 alkylaminosulfonyl, alkylaminosulfonylalkyl, di(alkyl)aminosulfonyl, di(alkyl)aminosulfonylalkyl, carboxyl, (hydroxyalkyl)carbonyl, (hydroxyalkoxy)carbonyl, trihalo substituted lower alkyl and trihalo substituted lower alkoxy;
- 10  $R_7$  is selected from the group consisting of alkyl, lower alkyl, alkoxy, lower alkoxy, alkenyl, alkynyl, heterocyclyl, heterocyclylalkyl, heterocyclylalkoxy, aryl, arylalkyl, arylalkoxy, OH, hydroxyalkyl, halogen, cyano, nitro, amino, alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, carbamoyl, acyl, acylalkyl, alkoxycarbonyl, alkoxycarbonylalkyl, acylamino, 15 alkylsulfonyl, alkylsulfonylamino, arylsulfonylamino (wherein aryl is substituted with 1 to 3 substituents independently selected from the group consisting of cyano, halogen, hydroxy, nitro, tri(halo)substituted lower alkyl and tri(halo)substituted lower alkoxy), carboxyl, (hydroxyalkyl)carbonyl, (hydroxyalkoxy)carbonyl, tri(halo)substituted lower alkyl and 20 tri(halo)substituted lower alkoxy;

- $R_8$  is selected from the group consisting of alkyl, OH, hydroxyalkyl, halogen, cyano, amino, alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino, carbamoyl, alkylcarbonylamino, alkylcarbonyl, 25 alkoxycarbonyl, (hydroxyalkyl)carbonyl, (hydroxyalkoxy)carbonyl,  $O(CH_2)_nR_5$ ,  $O(CH_2)_nO(CH_2)_mR_5$ ,  $O(CH_2)_nCH[(CH_2)_mR_5]_2$ ,  $O(CH_2)_nN[(CH_2)_mR_5]_2$ ,  $OCON[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nR_5$ ,  $NH(CH_2)_nCH(R_5)_2$ ,  $NH(CH_2)_nSO_2(CH_2)_mR_5$ ,  $NH(CH_2)_nO(CH_2)_mR_5$ ,  $NH(CH_2)_nOCH[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nO(CH_2)_mO(CH_2)_mR_5$ ,  $NH(CH_2)_nN[(CH_2)_mR_5]_2$ , 30  $NH(CH_2)_nSO_2NH(CH_2)_mR_5$ ,  $NH(CH_2)_nCH(OH)(CH_2)_mR_5$ ,  $NH(CH_2)_nCH(OH)(CH_2)_mOR_5$ ,  $NH(CH_2)_nCH(OH)(CH_2)_mN[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nCO(CH_2)_mN[(CH_2)_mR_5]_2$ ,  $NH(CH_2)_nCO_2(CH_2)_mR_5$ ,  $NH(CH_2)_nCO(CH_2)_mSO_2NH(CH_2)_mR_5$ ,  $NHCO(CH_2)_nCH(R_5)_2$ ,  $NHCO(CH_2)_nR_5$ ,  $NHCO(CH_2)_nO(CH_2)_mR_5$ ,

$\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{O}(\text{CH}_2)_m\text{R}_5$ ,  $\text{NHCO}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{CO}(\text{CH}_2)_m\text{R}_5$ ,  
 $\text{NHCO}(\text{CH}_2)_n\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ,  $\text{CONH}(\text{CH}_2)_n\text{O}(\text{CH}_2)_m\text{R}_5$ , and  
 $\text{CONH}(\text{CH}_2)_n\text{N}[(\text{CH}_2)_m\text{R}_5]_2$ ; wherein n is an integer from 0 to 6 and m is an  
 integer from 0 to 4; with the proviso, that m is at least 1 when  $\text{R}_5$  is selected  
 5 from the group consisting of OH, amino, alkylamino and di(alkyl)amino;

$\text{R}_5$  is selected from the group consisting of H, OH, lower alkyl, amino,  
 alkylamino, di(alkyl)amino, aryl, heteroaryl, biheteroaryl and heterocyclyl;  
 wherein aryl, heteroaryl and heterocyclyl are optionally substituted with 1 to  
 10 3 substituents independently selected from the group consisting of alkyl,  
 lower alkyl, acyl, carboxyl, aryl (optionally substituted with 1 to 5 halogen  
 substituents), OH, halogen, cyano, amino, alkylamino, di(alkyl)amino,  
 (hydroxyalkyl)amino, di(hydroxyalkyl)amino, alkylsulfonyl, aminosulfonyl,  
 alkylaminosulfonyl and aminosulfonylalkyl; and, wherein heterocyclyl is  
 15 further optionally substituted with 1 to 3 oxo substituents; and,

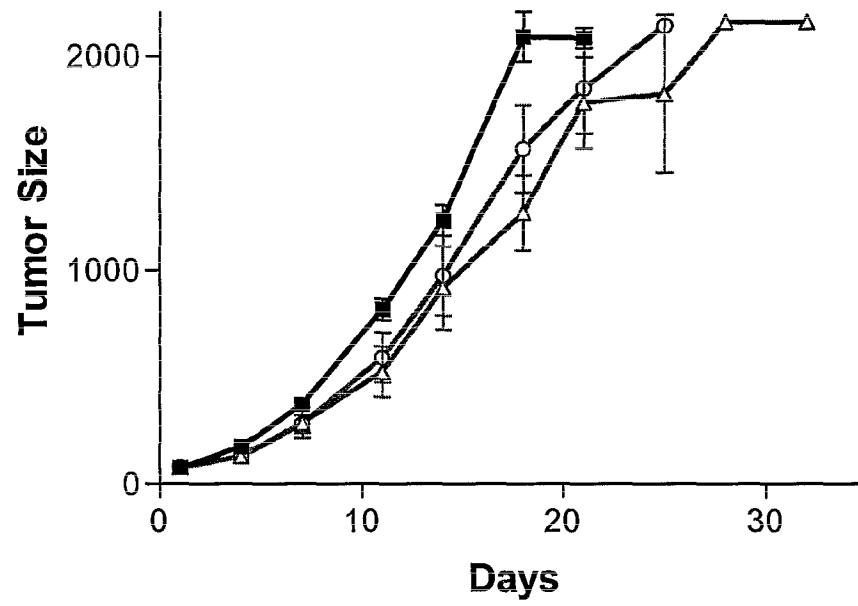
$\text{R}_3$  is selected from the group consisting of H, alkyl, lower alkyl, alkoxy, lower  
 alkoxy, alkenyl, alkynyl, heterocyclyl, heterocyclylalkyl, heterocyclylalkoxy,  
 aryl, arylalkyl, arylalkoxy, OH, hydroxyalkyl, halogen, cyano, nitro, amino,  
 20 alkylamino, di(alkyl)amino, (hydroxyalkyl)amino, di(hydroxyalkyl)amino,  
 carbamoyl, acyl, acylalkyl, alkoxycarbonyl, alkoxycarbonylalkyl, acylamino,  
 alkylsulfonyl, alkylsulfonylamino, arylsulfonylamino (wherein aryl is  
 substituted with 1 to 3 substituents independently selected from the group  
 consisting of cyano, halogen, hydroxy, nitro, tri(halo)substituted lower alkyl  
 25 and tri(halo)substituted lower alkoxy), carboxyl, (hydroxyalkyl)carbonyl,  
 (hydroxyalkoxy)carbonyl, tri(halo)substituted lower alkyl and  
 tri(halo)substituted lower alkoxy.

32. A pharmaceutical composition comprising a pharmaceutically acceptable  
 30 carrier and a compound of claim 1.

33. Use of the compound of claim 1 to inhibit a vascular endothelial growth  
 factor (VEGF) receptor tyrosine kinase.

34. The use of claim 33 to treat a disease selected from the group consisting of aberrant angiogenesis, tumors, diabetic retinopathy, rheumatoid arthritis, endometriosis and psoriasis.
- 5 35. Use of the compound of claim 1 to inhibit angiogenesis in a subject in need thereof.
36. Use of the compound of claim 1 to treat a cancer capable of stimulating angiogenesis in a subject in need thereof.
- 10 37. Use of the compound of claim 1 to treat diabetic retinopathy in a subject in need thereof.
38. Use of the compound of claim 1 to treat rheumatoid arthritis in a subject in need thereof.
- 15 39. Use of a compound of claim 1 to treat endometriosis in a subject in need thereof.
- 20 40. Use of a compound of claim 1 to treat psoriasis.
41. Use of a pharmaceutical composition comprising a compound of claim 1 to inhibit a vascular endothelial growth factor (VEGF) receptor tyrosine kinase.
- 25 42. The use of claim 41 wherein the pharmaceutical composition is used to treat a disease selected from the group consisting of aberrant angiogenesis, tumors, diabetic retinopathy, rheumatoid arthritis, endometriosis and psoriasis.
- 30

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## SEQUENCE LISTING

<110> Ortho-McNeil Pharmaceutical, Inc.

<120> Pyrazine Derivatives as Modulators of Tyrosine Kinases

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